OREGON
WATER
RESOURCES
DEPARTMENT

FEASIBILITY STUDY GRANTS

2019 GRANT APPLICATION

I. Study Information

Study Name: Gordon Creek Aquifer Storage and Recovery (ASR) Feasibility Study

Type of Feasibility Study:
☐ Water Conservation
☐ Reuse
☐ Storage (Above-Ground)
☒ Storage (Below-Ground)
☐ Storage (Other)

Requested Grant Amount (must be no more than 50% of Total Study Cost): $ 284,300

Total Cost of Feasibility Study: $ 586,400

Note: Request(s) may not exceed $500,000 per project.

II. Applicant Information

Applicant Name: Corbett Water District	**Co-Applicant Name:**
Address: PO Box 6	Address:
Corbett, OR 97019	
Phone: (503) 695-2284	Phone:
Fax:	Fax:
Email:	Email:

Principle Contact: Jeff Busto	**Fiscal Officer: Gail Griffith**
Address: same	Address: same
Phone:	Phone:
Fax:	Fax:
Email: cwd.jeff@gmail.com	Email: clerk.corbettwater@rconnects.com

Certification: I certify that this application is a true and accurate representation of the proposed work for a project feasibility study and that I am authorized to sign as the Applicant or Co-Applicant. By the following signature, the Applicant and Co-Applicant (if applicable) certifies that they are aware of the requirements of an Oregon Water Resources Department grant, have read and agree to all conditions within the sample Feasibility Study Grant Agreement and are prepared to conduct the study if awarded.

Signature of Applicant/Authorized Person: Date: 11-12-19

Print Name: Jeff Busto Title: District Manager

Signature of Co-Applicant/Authorized Person: Date:

Print Name: Title:

III. Feasibility Study Summary

1. Please provide a brief, 4-5 sentence summary of the feasibility study. This summary should include a brief description of the goal of the water conservation, reuse, or storage project being studied and the purpose of the study. Please refer to the Feasibility Study Grant Application Instructions for additional information on what to include in your study summary.

   This proposed study would assess the feasibility of using Aquifer Storage and Recovery (ASR) for storing water from Gordon Creek for use during the source limited times of the year to support municipal water supply for the Corbett Water District (CWD). The study would design and construct an exploratory test well to evaluate the hydraulic properties of the aquifer and the geochemical compatibility between the surface water and the groundwater, and assess the feasibility of the groundwater resource and an ASR well. The study would also provide the storage-specific study requirements as required for projects that divert water from a stream that supports sensitive, threatened or endangered species. The proposed study would also assess the feasibility of a water supply well constructed into the Columbia River Basalt Aquifer. Information from the study will guide the CWD with its decision on whether to proceed with utilizing the groundwater resource to supplement the existing surface water supply resource because other water supply alternatives are not available.

IV. Study Location

Instructions: Please answer the following questions about the location of the feasibility study and project being evaluated.

2. Please provide the following information about the study and project location.
   a. Latitude/Longitude (in decimal degrees): 45-30-39.18 N/ 122-11-53.58 W
   b. County: Multnomah
   c. Watershed/Basin (HUC 10 number): 1708000108

3. Please attach a site plan map showing the following and label as Attachment #1:
   a. Feasibility study area boundaries
   b. Project area (if implemented)
   c. True north arrow
   d. Map title and legend
   e. Latitude and longitude
   f. Property boundaries
   g. Surface water bodies
   h. Sampling locations (if proposed)
   i. Points of Diversion and Place of Use, labeled for each water right (if applicable)

4. Check the box which best describes the properties involved in the proposed Feasibility Study.
   a. ☐This Feasibility Study will not impact or access lands.
   b. ☒This Feasibility Study will impact or access lands. Complete the table below to identify any properties where access is required for the feasibility study or on which the study would occur. *Add rows as needed.*

Tax Map Number	**Tax Lot Number**	**Ownership Type (✓ One)**	**Property Owner of Record**
	1S5E04-01500	☐Public ☒Private	Jeffrey Hargens and Linda Hargens
		☐Public ☐Private	
		☐Public ☐Private	
		☐Public ☐Private	
		☐Public ☐Private	

5. Attach a signed Landowner Agreement form for each property listed in Question #4 where access to the property is required or on which the Feasibility Study would occur. Attach Landowner Agreement form(s) only for those properties involved in the Feasibility Study and label Attachment #2. (Landowner Agreement forms may be found on the Applications, Forms and Guidance webpage.)
   a. Where a single landowner entity is the owner of record for multiple properties, one form may list the multiple properties owned by that entity.

   b. For *public* lands attach the landowner form or other documented authorization from the federal or state government property owner allowing the feasibility study activities **or** documentation that demonstrates such authorization is being pursued.

6. Check the box which best describes the properties involved in future project Implementation. Identify any lands that would be impacted or accessed during future project implementation. Check all that apply and provide the requested information.
   a. ☒The proposed project, if implemented, will only impact or access lands already identified in Question 4 (must have selected box b under question 4).

   b. ☐The proposed project, if implemented, will likely impact or access lands during implementation, but those lands likely to be accessed or impacted have not been identified, OR this question is not applicable. If this box (6b) is checked, do not complete the table below.

   c. ☐The proposed project, if implemented, is highly likely to impact or access additional lands during implementation. If this box (6c) is checked, complete the table below to identify any additional properties (those not already identified under question (4)) where access is required for future project implementation. *Add rows as needed. No Landowner Agreement forms are required for lands listed only under this question.*

Tax Map Number	Tax Lot Number	Ownership Type (✓ One)	Property Owner of Record
		☐Public ☐Private	
		☐Public ☐Private	
		☐Public ☐Private	
		☐Public ☐Private	
		☐Public ☐Private	

V. Feasibility Study Specifics

Instructions: Please answer all questions in this section. As applications are expected to result in additional pages to complete this section, you may attach your responses on a separate document as long as you indicate the question numbers in your response.

Study Description, Needs, and Goals

7. Describe the feasibility study goal.

The goal of the study is to determine the feasibility of installing an Aquifer Storage and Recovery (ASR) well in the upper elevations of the Corbett Water District (CWD). This goal will be accomplished by drilling an exploratory test well, characterizing the geologic, hydraulic and geochemical characteristics of the receiving water in the target aquifer, assessing the viability of using Gordon Creek as source water for ASR, and determining the long-term sustainability of an alternative source for municipal water supply. Favorable results from the feasibility study will confirm CWD's approach to using ASR for the additional water storage needed to serve the district currently and into the future.

The surface water source for the CWD has shown vulnerability in recent years. The sole water source is surface water diversions from Gordon Creek, including both the North Fork and the South Fork (Water Right Certificates No. 81430 and No. 81431). In 2016-2017, logging occurred in the South Fork basin and since then surface flows have gradually declined, to the point that, in 2019, creek flow was too low to withdraw any water. Creek flows in both forks have also become "flashy" due to changing climate patterns, meaning quicker peaks during the wet season and lower summer flows.

In addition, Gordon Creek is a tributary to the Sandy River which contains threatened and endangered fish species. ASR is being considered since groundwater availability is limited within the Sandy River Basin by Oregon Administrative Rule (OAR) 690-503. An ASR well could provide environmental benefits by using ASR water to augment river flows and enhance in-stream flows in Gordon Creek.

In addition to studying the feasibility of an ASR well, the feasibility of constructing a production well as a redundant groundwater source would also be studied. If the CWD were to lose its sole water supply due to contamination of Gordon Creek, it would create a water emergency and put the welfare of the entire community at risk. The viability of the watershed was threatened during the Eagle Creek fire, and other threats could occur in the future due to a variety of causes. A new well source would provide redundancy to the system and avoid the potential total loss of the District's water source. A new groundwater source or ASR system would provide redundancy to the system and both options could be evaluated using essentially the same data set.

If feasible, an ASR well would be a cost-effective and environmentally sustainable approach for storing water, and preliminary studies suggest that an ASR is feasible. Please refer to the attachments to this application for additional information on alternatives that have been considered.

8. Describe how the proposed study would achieve the goal.

The goal of this study is to determine the feasibility of an ASR and/or production well. To achieve this goal, the study will include:

- Installation of an exploratory test well.
- Evaluation of hydraulic and geochemical properties of the receiving target aquifer for ASR.
- Analysis of environmental aspects of supplying the ASR from Gordon Creek and how the project will serve the CWD's future water demand (i.e. the storage-specific study requirements).
- Preparation of a feasibility analysis for an ASR well.

With this information the overall project feasibility of an ASR well can be established. A more detailed task list of these bulleted work items is provided in response to Question 14 of this grant application.

9. Describe the identified water need (local, regional, or statewide). Please provide data or a narrative substantiating the need.

The CWD provides municipal water service to a rural area of Multnomah County that lies east of the Sandy River, south of I-84, north of Gordon Creek (a tributary to the Sandy River), and west of a US Forest Service area (generally known as Larch Mountain). The District area extends about 9 miles east-west and about 2.4 miles north-south, encompassing an area of about 22 square miles. It serves a population of about 3,200 people using a gravity fed distribution system.

Maximum capacity of the District's water treatment plant is 650 gpm. During the summer, peak demand is 1,000 gpm - 1,200 gpm. The excess demand is accommodated by drawing out of Reservoir #6, which then recovers during the night when less water is being used. Refilling Reservoir #6 is difficult during the summer, even at full water production. If an event were to occur at the treatment plant during the summer that compromised the water plant and limited water production, such as the plugging of a filter pond, the reservoir could run dry and create a water emergency. For example, last winter (2018-2019) a filter pond plugged that reduced water production to 350 gpm. Fortunately, this occurred during the winter. If this would have happened during a summer month, Reservoir #6 would likely have run dry.

An ASR would provide the additional water storage to accommodate peak demand without drawing down Reservoir #6 beyond the point of recovery. With an ASR, water stored in the ground could be pumped out of the ground and added back into the system to accommodate the excess demand. It would also enable drawing less water out of Gordon Creek which may be beneficial for ecological flows for the sensitive, threatened or endangered fish species in the Sandy River. This potential benefit will be studied in more detail with the feasibility study.

Other alternatives have already been investigated (see attached exhibits). Each of the other alternatives have been found not to be ideal for various reasons. This includes:

- Development of a new groundwater source at various locations within the District.
- Construction of above-ground reservoirs at various locations within the District
- Tying into other municipal water sources in the area.

An ASR well and/or a well into the deep Columbia River Basalts aquifer has evolved as the most viable due to its location at the higher elevation of the district, its proximity for connection to the water system, and availability of 3-phase power.

Long-term projections for water demand were presented in the latest Master Water Plan update. It was concluded that growth in the District is expected to be slight in the foreseeable future, which is consistent with what the District has experienced during the latest economic growth period. Accordingly, if feasible, an ASR well would serve the community's water storage needs far into the future.

10. <u>Please provide evidence that water is available to meet the above described need. Evidence can include regulatory and physical information regarding water availability.</u>

Gordon Creek will be the water source for the ASR. CWD has surface water rights for 2.0 cfs at both the South Fork and the North Fork headworks. The existing treatment plant has the capacity to treat 1.45 cfs (equivalent to 342 MG/year or 650 gpm), so system capacity is not restricted by water rights.

In 2018 (the most current record available) CWD pulled 270 MG from Gordon Creek and ran it through the treatment plant. Of the 270 MG that was treated, 160 MG was delivered and 110 MG was returned to the creek. Accordingly, 110 MG of treated source water annually would easily be available for ASR without exceeding treatment facility capacity or existing water right allocations.

In July of 2019 the CWD attended a pre-application meeting with OWRD to discuss ASR and the potential for groundwater rights. The meeting was attended by Amy Landvoigt (District 20 Watermaster) and Dennis Orlowski (Hydrogeologist). The overall sentiment from the meeting was that water rights for a deep water well into the Columbia River Basalts and a limited license ASR could both be feasible, but conditions may be required for construction of the well based on encountered hydraulic conditions.

11. <u>Describe the level of community support and commitment associated with the study. This may include any collaborative water planning efforts undertaken to identify the project or study.</u>

The communities of Corbett and Springdale are both supportive of the idea to secure an alternate source of potable drinking water. This topic has been discussed at many CWD monthly board meetings, which are open to the public and for which meeting agendas are posted on the CWD website. Several environmental organizations with interest in the Gordon Creek Watershed also support lessening impact on fish and wildlife that depend on the same surface streams that provide raw water to the district for treatment.

12. <u>Describe how implementation of the project could benefit and/or impact the community.</u>

The current surface water source is subject to climactic variability, timber harvesting and natural disasters with wildfire being the greatest concern. If implemented, this project would allow storage of large quantities of water below ground. Above ground storage (reservoir capacity) is far below the recommended percentage of storage versus daily demand. CWD currently has a maximum of two days of storage available, leaving the community without fire protection from fire hydrants and no water to use for drinking and cooking if the source is compromised. Should this study also determine that a deep water well is possible, it will provide a sustainable redundant source of safe, clean potable water to the communities for many generations to come.

An increase in water rates would be a result from the implemented project. The District is very aware of how a rate increase can impact its customers. Cost estimates have been prepared for the implemented project so that rate increases could be projected under various funding scenarios. The Board of Commissioners has voted to move forward with the project and accept a future rate increase in order to finance the implemented project.

13. List letters of support (name and/or affiliation of sender). Attach copies of the letters to your application.

    - Corbett School District
    - Oregon State Parks
    - Corbett Fire District #14

Study Key Tasks

14. Identify the study key tasks necessary to conduct the feasibility study using the following format and including as many tasks as necessary to complete the study. In the event that your study receives grant funding, the key tasks identified will be incorporated into your grant agreement as the "Statement of Work." Please note: Project management and administration are common functions within a specified key task and not separate key tasks themselves.

Task number. Key Task Title

- Task schedule: The approximate dates during which the key task will be completed.
- Description of key task activities: Include specific details of the task such as task purpose, planned approach, appropriate technical information, proposed methods, and rationale for the approach.
- Qualified personnel that will complete task: Include a description of the professional experience, professional qualifications and licensure of personnel necessary for task work.

Task 1: Environmental and Land Use Review

- Task schedule: May 2019 – September 2019
- Description of key task activities: Environmental and land use reviews were performed in 2019. The purpose of this work was to confirm that the selected site did not have fatal flaws.
    - A Pre-Application conference was held with Multnomah County to determine land-use requirements that will apply to the project. Information was provided at the meeting that confirmed the project would be allowed as a Community Conditional Use in the CFU-4 zone (Commercial Forestry Unit 4).

    - An Environmental Review was prepared that assessed how the preferred alternative would affect the environment and assessed the environmental consequences of the proposed project. It was determined that the project site does not contain any wetlands or other federally regulated resources. No environmental effects were identified if the project were to be implemented.
    - A Cultural Resources Investigation was completed in accordance with the requirements of Section 106 of the National Historic Preservation Act (NRHP). The investigation of this project area entailed background research, an assessment of visual impacts, a surface survey, and subsurface surveys. This work resulted in the identification of no cultural resources that may be affected, directly or indirectly, by the proposed project, and recommended a determination of No Effect upon Historic Properties for the project.
- Qualified personnel:
    - **Eric Eisemann, J.D. Sole Proprietor/Senior Planner, E2 Land Use Planning**: Eric Eisemann advises local governments about complex land use planning issues. He has considerable experience securing land use approvals for projects on rural lands in Multnomah County and has a thorough understanding of the land use processes applicable to this project.
    - **John van Staveren, Wetland Scientist/Biologist, Pacific Habitat Services**: Mr. van Staveren directs environmental and regulatory compliance activities for an environmental consulting firm local to the project area. He has conducted over 1,000 wetland delineations, 30 Local Wetland Inventories and riparian inventories, and has designed and implemented dozens of freshwater and estuarine wetland mitigation plans.
    - **Alexander Gall, M.A., RPA, Principal Investigator, Archaeological Services**, LLC: Mr. Gall has acted as Principal Investigator/Project Manager on over 1,200 cultural resources projects of all types and sizes throughout the project area.

Task 2: Design Exploratory Test Well for ASR and Production Well

- Task schedule: November 2019 – January 2020
- Description of key task activities: A single exploratory test well will be used for evaluation of both ASR and water production. A design for the exploratory test well will be developed based on the anticipated geologic and hydrogeologic conditions from available and inferred data, water well information, and geologic and hydrogeologic reports near the project test area. The purpose of the test well is to confirm sufficient water quantity and acceptable water quality are present for drinking water use and to identify potential limitations of utilizing the basalt aquifer(s) present in the project area for long term sustainable water supply and/or ASR.
- Qualified personnel: **Christopher Augustine, RG, CWRE, Project Director, SCS Engineers**: Mr. Augustine has over 18 years of experience as a consulting hydrogeologist delivering water supply and storage projects. He has extensive technical expertise with all aspects of ASR feasibility and operation in the CRBG aquifers in Oregon and Washington, aquifer recharge (AR), drilling of deep high capacity wells, water rights and ASR/AR permitting, geochemical evaluation and advanced single and multi-well pumping test analysis.

Task 3: Drill and Construct an Exploratory Test Well

- Task schedule: January 2020 – October 2020
- Description of key task activities:

  Following preparation of the engineering plans and specifications, bids will be advertised to drill and construct an exploratory test well. A contract to complete the work will be awarded to the lowest responsible bidder. This task will include:
  - Drill and construct a test well.
  - Evaluate geologic and hydrogeologic conditions encountered during test well installation for suitability of a production well and ASR.
    - Sample and analyze the encountered Columbia River Basalt Group (CRBG) stratigraphy
    - Evaluate and infer basalt flow and interflow stratigraphy in hand specimen
    - Identify water bearing zone(s)
    - Identify changes in hydraulic head between water bearing zones (if any) during drilling to evaluate the potential for co-mingling of aquifers
    - Evaluate key water quality parameters during drilling
    - Perform video survey of the open borehole portion of the well to confirm stratigraphic and structural interpretations inferred from drill cuttings and qualitatively evaluate intra-borehole flow
  - Geologic and hydrogeologic data will be shared with the OWRD and the United States Geologic Survey (USGS) to supplement the CRBG knowledge in the region. After petrographic examination of in hand specimen, drill cuttings will be submitted for geochemical analysis by x-ray fluorescence (XRF) at a qualified laboratory.
  - Water quality in the CRBG may have concentrations of minerals that exceed regulatory requirements for drinking water and suitability for use as potable water supply without treatment. Water quality samples will be collected to evaluate changes in water quality with depth. Co-mingling of water bearing zones will be evaluated qualitatively using down hole video survey methods.
  - Based on those observations, discrete water quality sampling and geophysical methods to evaluate zonal contributions and/or intraborehole flow may also be recommended as part of Task 4 below.
- Qualified personnel:
  - A qualified well driller.
  - **Christopher Augustine, RG, CWRE, Project Director, SCS Engineers**: Mr. Augustine has over 18 years of experience as a consulting hydrogeologist delivering water supply and storage projects. He has extensive technical expertise with all aspects of ASR feasibility and operation in the CRBG aquifers in Oregon and Washington, aquifer recharge (AR), drilling of deep high capacity wells, water rights and ASR/AR permitting, geochemical evaluation and advanced single and multi-well pumping test analysis.

Task 4: Evaluate Exploratory Test Well Hydraulic Properties

- Task schedule: December 2020 – January 2021
- Description of key task activities: On the basis of observations during the drilling and construction, a long duration constant rate pumping test and geophysical testing program will be developed. The purpose of the testing program will be to estimate target aquifer properties such as specific capacity, bulk, and zonal transmissivity of the water bearing zones, and identify aquifer boundary conditions, if present. Long-term sustainability of the groundwater resource for municipal water supply and ASR feasibility will be evaluated based on the observed hydraulic response.

  Key objectives of this task include:
    - Determine hydraulic properties of the encountered aquifers.
    - Identify hydrogeologic boundaries such as recharge or flow-limiting boundaries.
    - Evaluate water quality and/or changes in key water quality parameters with pumping.
    - Evaluate zonal transmissivity and contribution of individual water bearing zones.
    - Observe recovery and long-term water level trends after pumping test is completed.

  Standard pumping test design and analysis will be performed to evaluate well performance, aquifer properties and sustainability of the groundwater resource. If boundary conditions are identified during the pumping test, more advanced reservoir modeling methods of analysis such as derivative analysis may be used to evaluate the potential for the groundwater resource.

  Static and dynamic geophysical and geochemical profiling of the well may be performed as part of this task based on observations from Task 3. Flow profiling, using a dye tracing method or geophysical flow evaluation using a spinner log, will be used to estimate zonal contributions of the individual water bearing zones and identify vertical intraborehole flow, if present. If poorer water quality zones are observed during drilling, discrete geochemical samples may also be performed.

- Qualified personnel: **Christopher Augustine, RG, CWRE, Project Director, SCS Engineers**: Mr. Augustine has over 18 years of experience as a consulting hydrogeologist delivering water supply and storage projects with extensive technical expertise in all aspects of ASR feasibility and operation including analytical modeling of highly bounded and compartmentalized aquifers. Mr. Augustine has prior experience in both Oregon and Washington with evaluation and feasibility of both water quality- and quantity-limited ASR test wells.

Task 5: Evaluate Geochemical Compatibility for ASR

- Task schedule: December 2020
- Description of key task activities: An analytical program will be designed to support an assessment of geochemical compatibility and any additional treatment requirements to allow underground storage of treated surface water. The geochemical assessment will focus on primary physical parameters, cations, anions, and select metals likely to be present in surface water with the potential to interact with the subsurface.

  Specific activities include:
    - Collect a full suite of primary and secondary drinking water contaminants of groundwater to DEQ and OHA standard in the water bearing zones.
    - Perform a geochemical and biological assessment of the test well to determine the potential for adverse geochemical reactions during injection, biological clogging and potential for failure of the well.

    - Identify additional treatment, distribution system flushing, or source water polishing needed to prevent biological or physical clogging of the well during ASR injection.

  Samples will be collected in compliance with accepted sampling protocols and analytical methods typically used in ASR monitoring plans and quality assurance project plans. A groundwater quality sample will be collected and analyzed for a full suite of geochemical parameters to establish existing water quality, compare water quality with regulatory standards, and evaluate if potential for biological clogging of the well and/or aquifer is present. The source water sample will be similar to the groundwater list of analytes and will focus on constituents sometimes found in treated surface water such as turbidity, nitrate, and pathogens. As noted above, a biological assessment of iron-related, sulfate-reducing and slime-forming bacteria will be collected and analyzed from the source water in the distribution system near the project area.

  The water quality analyses of both source and receiving water will be used to compare their chemistries to other basalt-hosted ASR projects and perform simple bulk mixing modeling with the USGS geochemical modeling software PHREEQC. This will be used to determine whether additional geochemical compatibility is a concern for feasibility and will also be used in design of the ASR injection system if additional pre-treatment or disinfection is required (i.e. booster chlorination, etc.).

- Qualified personnel: **Christopher Augustine, RG, CWRE, Project Director, SCS Engineers**: Mr. Augustine has extensive technical expertise with all aspects of ASR feasibility and operation including geochemical evaluation and identification of biofouling potential and well rehabilitation of biofouled water supply and ASR wells in the northwest, particularly in the basalt wells in the Portland and Tualatin basins. He has developed innovative methods to allow for operation and maintenance of water supply and ASR wells with a history of biofouling occurrence, including newly constructed water supply and ASR wells in the Portland Basin. He will evaluate groundwater quality, bacteriological communities in the distribution system and test well and perform geochemical reaction modeling of source water with native groundwater.

Task 6: Storage-Specific Study Requirements

- Task schedule: November 2020 – February 2021
- Description of key task activities: Gordon Creek is a tributary stream to the Sandy River, which supports sensitive, threatened or endangered fish species. Since the project will divert water from Gordon Creek it triggers one of the criteria for providing storage-specific study requirements. The purpose of providing the storage-specific study requirements will be to ensure that construction of the water storage project will not harm ecological or environmental resources, to identify opportunities to mitigate possible environmental harm, and to confirm that the project is compatible with future CWD projects to serve the long-term water needs of the community.

  The Storage-Specific Study will address the following requirements:
    - Provide an Analysis of Ecological Flows, including an assessment of the impact that diverting flows has on bypass, optimum peak, and flushing flows.
    - Provide a Comparative Analyses of Alternative Means of Supplying Water, including development of a list of alternative means of supplying water and providing a comparison of the alternative means of supplying water with the proposed ASR project.

- Provide an Analysis of Environmental Harm or Impact. A Cultural Resource Survey and an Environmental Review have already been prepared for the project (Task 1). These studies indicate that no environmental harm and no affects to cultural resources will result from construction of the project. (See Exhibits ‘C’ and ‘D’.) The results of these studies will be included in the report.
- Provide an evaluation of Need and Ability to Augment Instream Flows.
  - An analysis will be provided to determine the need to augment instream flows to conserve, maintain and enhance aquatic life and any other ecological values. Summaries of water available in the basin and streamflow that is legally protected by existing instream water rights or scenic waterways within the stream reach of interest or downstream of the project area will be included. The impact of the proposed storage project on these items (i.e., water availability and by-pass, optimum peak, flushing, and other ecological flows) will be evaluated and the need to augment instream flows to help meet ecological flows will be evaluated.
  - An analysis will be provided for the feasibility of instream flow augmentation to Gordon Creek from the project. The study analyses will include a hydrologic analysis of the area above the project, an analysis of the project’s storage capabilities throughout the year, and an evaluation of the feasibility of if/how the project can operate to augment instream flows.
- Provide an Analysis Related to Municipal Use. The Corbett Water District is a municipal water supply and this special study requirement applies to this project.
  - An evaluation of future local and regional water demand will be provided. This will include an analysis of existing data/reports of estimated municipal water demand, including the adopted Water Master Plan, and how the project would impact other nearby communities.
  - The relationship of the proposed storage project to existing and planned infrastructure projects will be studied. The study will review the District’s CIP and the Water Master Plan and discuss strategies to address water and infrastructure needs.

- Qualified personnel:

  Shane Latimer, PhD CSE, SCS Engineers: Dr. Latimer is an environmental planner, ecologist, and toxicologist with over 30 years of experience in environmental assessment, planning, permitting, and implementation. His specialty is developing projects that challenge the interface between the built and natural environment, including municipal drinking water facilities. These projects often require careful assessments of alternatives, impacts, and opportunities to successfully navigate the applicable public regulatory processes (e.g., NEPA, local land use, etc.) while ensuring environmental integrity. Dr. Latimer has a thorough understanding of engineering concepts and practices and is adept at working collaboratively with engineers and other professionals to ensure an optimum balance between environmental and engineering constraints. A main area of focus of Dr. Latimer's work during the last 25 years has been planning, permitting, and implementation of large projects that require substantial compensatory mitigation of wetlands and waters, as well as stand-alone ecological restoration projects. Many of these projects typically include significant issues related to species listed under the Endangered Species Act (e.g., salmonid fish), fish passage, floodplains, riparian zones, stream flows, stormwater treatment, water rights, and ecological integrity, often in the context of water use.

  Tim Shell, PE, Senior Engineer, Wallis Engineering: Mr. Shell has over 30 years experience in the design and construction of municipal water supply systems, including roles as both a consulting engineer and a public works director. Mr. Shell has been responsible for overseeing the development and implementation of water master plans for various municipalities and has been working with the Corbett Water District on this project for over a year.

Task 7. Evaluate Aquifer and ASR Feasibility

- Task schedule: November 2020 – February 2021
- Description of key task activities: Information from the test well drilling and testing programs will be integrated into available geologic and hydrogeologic information compiled by Yinger and Associates (2016) and SCS (2018). The data will be used to determine the long-term feasibility for groundwater resources as a viable solution to meet future supply and storage demands for the CWD.

  Specific activities include:
    - Evaluate the hydrogeologic conceptual model and flow regime of the aquifer.
    - Estimate well performance during pumping and injection to develop:
        - Target pumping rates, drawdown and pumping levels during production.
        - Target injection rates, build-up and recharge levels during injection.
    - Estimate design parameters for a large diameter production well.
    - Estimate target storage volumes, the potential for loss of stored water, and the radius of influence of the ASR well (i.e. potential for well interference).
    - Preparation of draft and final reports.
- Qualified personnel: **Christopher Augustine, RG, CWRE, Project Director, SCS Engineers**: Mr. Augustine has 18 years of technical expertise working on projects that involve all aspects of ASR feasibility and operation including evaluating pumping test data in complex geologic settings in both Oregon and Washington. He has extensive experience using advanced aquifer test analytical methods to evaluate well performance, aquifer properties, aquifer geometry and boundaries, ASR feasibility for water supply wells and reservoir potential and optimization for water supply and ASR wellfields.

15. Study Task Scheduling – Estimated duration of feasibility study: May 2019 to February 2021

Place an “X” in the appropriate column to indicate when each task of the project would take place. Study tasks should match those listed as part of your response to the previous question.

Feasibility Study Key Tasks (Add additional rows as needed)	**Grant year**				**Grant year**				**Grant year**			
	2019				2020				2021			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Environmental and Land Use Review	☐	☒	☒	☐	☐	☐	☐	☐	☐	☐	☐	☐
Design Exploratory Test Well for ASR and Production Well	☐	☐	☐	☒	☒	☐	☐	☐	☐	☐	☐	☐
Drill and Construct an Exploratory Test Well	☐	☐	☐	☐	☒	☒	☒	☒	☐	☐	☐	☐
Evaluate Exploratory Test Well Hydraulic Properties	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
Evaluate Geochemical Compatibility for ASR	☐	☐	☐	☐	☐	☐	☐	☒	☐	☐	☐	☐
Storage-Specific Study Requirements	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐
Evaluate Aquifer and ASR Feasibility	☐	☐	☐	☐	☐	☐	☐	☒	☒	☐	☐	☐

Permits and Regulatory Approvals

16. Identify any water rights required needed to complete the proposed Feasibility Study below. Check all of the following that apply and provide the information requested:
    a. ☒ No water rights are required to complete the proposed study.
    b. ☐ The proposed study requires a new water right or other water right transactions. If checked, list the transaction(s) required (e.g., new right, transfer, etc.):
    c. ☐ The applicant has legal access to a water right that will be used to conduct the study. The proposed study requires a water right, and the applicant holds or has been given permission to utilize the water right(s) for the proposed study. If checked, list all water rights required for the study in the table below, adding rows as needed. See the Application Instructions for further guidance, including how to find water right information.

Water Right Number (Include prefixes, if applicable, e.g., CW 12345)	**Is this an application, permit, certificate, limited license, special or final order, transfer, decree, lease, or claim?**	**Tax Lot IDs within the Place of Use where water will be used to complete the study**

17. Identify any water rights needed to implement the proposed Project below. Check all of the following that apply and provide the information requested:
    a. ☐ The applicant does not know what water rights or water right transactions are required for the project. That will be determined through this study or other effort at a future date.
    b. ☒ The proposed project requires a new water right or other water right transactions. If checked, list transaction(s) required (e.g., new right, transfer, etc.):

c. ☐ The applicants holds the water right(s) required for the project. If checked, include list of rights in the table below, adding rows as needed. See the Application Instructions for further instruction, including how to find water right information.

Water Right Number (Include prefixes, if applicable, e.g., G 00010)	**Is this an application, permit, certificate, limited license, special or final order, transfer, decree, lease, or claim?**	**Water Right Amount**			**Tax Lot IDs within the Place of Use where water will be used to implement the proposed project**
		Max Volume (ac-ft)	**Max Rate (cfs)**	**Duty (ac-ft/ac)**	
	Limited License for ASR				1S5E04-01500

18. Provide a list of any other permits and regulatory approvals needed to conduct the Feasibility Study and indicate the status of each in the table below. If permits/approvals are required, please submit copies of secured permits/approvals **or** describe efforts to secure permits/approvals including status. If no permits or authorizations are required for the study, provide an explanation:

Study Permit/ Regulatory Approval	**Status and Efforts To Date**
None required	

19. Provide a list of the permits and regulatory approvals that you anticipate would be needed to implement the proposed project being studied. If permits/approvals are not required, please explain why and provide information regarding any agencies contacted to verify this determination:

Project Permit/Regulatory Approval *(add rows as needed)*
Community Service Conditional Use Permit from Multnomah County
Multnomah County Design Review

VI. Feasibility Study Budget

Instructions: Please answer the following questions about the study budget using the tables provided.

20. Please provide an estimated line item budget for the proposed feasibility study. Examples include: Direct project specific costs, such as in-house staff salary, contractual services, and administrative costs. See the Department's Budget Procedures and Allowable Costs for further guidance.

OVERALL STUDY BUDGET Line Items	**Number of Units*** *(e.g. # of Hours)*	**Unit Cost** *(e.g. hourly rate)*	**In-Kind Match**	**Cash Match Funds**	**OWRD Grant Funds**	**Total Cost**
Staff Salary/Benefits			$5,000			$5,000
Contractual/Consulting				$292,100	$279,300	$571,400
Equipment (must be approved)						
Supplies						
Travel						
Other:						
Administrative Costs**				$5,000	$5,000	$10,000
		Total	**$5,000**	**$297,100**	**$284,300**	**$586,400**

** The "Unit" should be per "hour" or "day" – not per "project" or "contract."* *<u>Units x Unit Costs = Total Cost</u>*
*** Administrative Costs may not exceed 10% of the total funding requested from the Department*

21. Identify the budget for each key task below. Key tasks identified below should be the same as the key tasks identified in Questions 14 and 15.

Feasibility Study Key Tasks (Add additional rows as needed)	**In-Kind Match**	**Cash Match Funds**	**OWRD Grant Funds**	**Total Cost**
Task 1: Environmental and Land Use Review		$25,100	$7,300	$32,400
Task 2: Design Exploratory Test Well for ASR and Production Well		$10,000	$10,000	$20,000
Task 3: Drill and Construct an Exploratory Test Well	$5,000	$196,000	$201,000	$402,000
Task 4: Evaluate Exploratory Test Well Hydraulic Properties		$37,500	$37,500	$75,000
Task 5: Evaluate Geochemical Compatibility for ASR		$6,000	$6,000	$12,000
Task 6: Storage-Specific Study Requirements		$10,000	$10,000	$20,000
Task 7: Evaluate Aquifer and ASR Feasibility		$7,500	$7,500	$15,000
Administrative Costs		$5,000	$5,000	$10,000
Total	**$5,000**	**$297,100**	**$284,300**	**$586,400**

VII. Match Funding

Instructions: Please answer the following question regarding matching funds.

22. Please fill out the table below and attach the appropriate documentation for both the secured and pending match (add rows as needed). Keep in mind that applicants must demonstrate a minimum **dollar-for-dollar match**. Please note that a failure to meet this requirement or to attach documentation will result in an incomplete application that will not be considered for funding.

    For secured funding, you must *<u>attach a letter of support or award</u>* from the match funding source that specifically mentions the dollar amount identified for this study and as shown in the "Amount/Dollar Value" column in the table below.

For pending resources, *other written documentation showing a request* for the matching funds must accompany the application or documentation must identify the date on which a future funding application will be submitted, identify the funding program, and provide evidence that the project is eligible for the funding program identified.

Match Funding Source (if in-kind, briefly describe the nature of the contribution)	**Type (✓ One)**	**Status (✓ One)**	**Amount/ Dollar Value**	**Date Match Funds Available** *(Month/Year)*
Prepare site for installation of test well	☐cash ☒in-kind	☐secured ☐pending	$5,000	06/2020
2019-2020 Budget	☐cash ☐in-kind	☒secured ☐pending	$250,000	
2020-2021 Budget	☐cash ☐in-kind	☐secured ☒pending	$47,100	
	☐cash ☐in-kind	☐secured ☐pending		
	☐cash ☐in-kind	☐secured ☐pending		

VIII. Storage-Specific Questions

Instructions: If you indicated that your study is for a storage project, answer question 23 in this section. If your study is for above-ground storage, also answer question 24. Please refer to the document on Storage-Specific Study Requirements for guidance and information on completing this section, available on the OWRD Funding Opportunities, Applications, Forms, and Guidance webpage. If your study is for a water conservation or reuse project, skip this section.

23. Answer the following "Yes/No" questions about the storage project to be evaluated in the proposed study.

    A. Will the project divert more than 500 acre-feet of surface water annually? Yes ☐ No ☒

    B. Will the project impound surface water on a perennial stream? Yes ☐ No ☒

    C. Will the project divert water from a stream that supports sensitive, threatened or endangered species? Yes ☒ No ☐

    If you answered "yes" to any of the questions above, you are required to address the following analyses in your feasibility study. By signing this application, you are committing to include these required elements in your feasibility study.

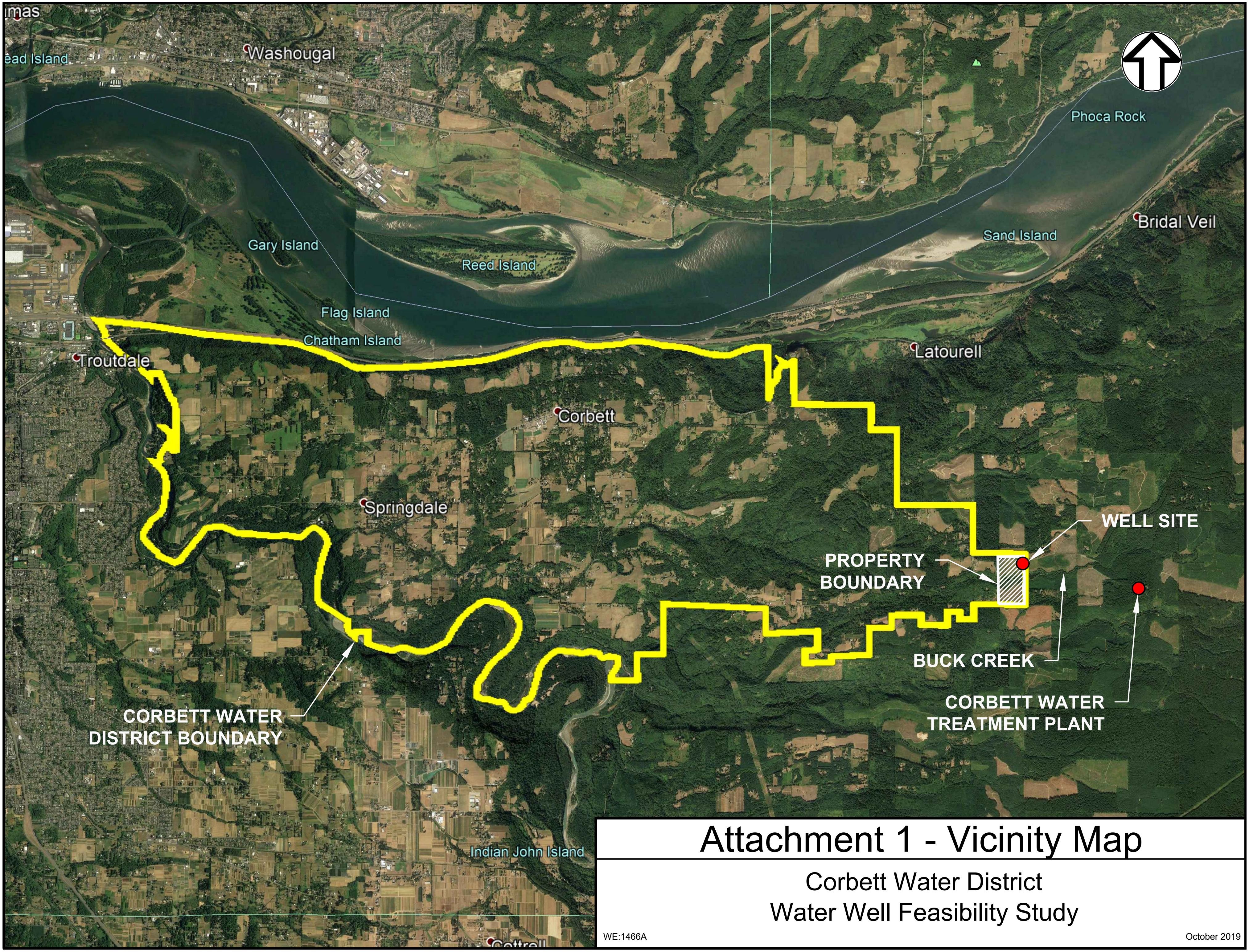
    If you answered "yes" to (A), (B), or (C) above, attach a description of how you intend to address the following required elements in your feasibility study (please refer to the document on Storage-Specific Study Requirements for guidance and a description of the minimum acceptable standards regarding these study requirements):

i. Analyses of by-pass, optimum peak, flushing and other ecological flows of the affected stream and the impact of the storage project on those flows.
ii. Comparative analyses of alternative means of supplying water, including but not limited to the costs and benefits of water conservation and efficiency alternatives and the extent to which long-term water supply needs may be met using those alternatives.
iii. Analyses of environmental harm or impacts from the proposed storage project.
iv. Evaluation of the need for and feasibility of using stored water to augment instream flows to conserve, maintain and enhance aquatic life, fish life and any other ecological values.
v. *For proposed storage projects for municipal use only* **–** For a proposed storage project that is for municipal use, analysis of local and regional water demand and the proposed storage project's relationship to existing and planned water supply projects.

24. **For Above-Ground Storage Only:** Describe whether or not the storage project would include provisions for using stored water to augment instream flows to conserve, maintain and enhance aquatic life, fish life or other ecological values. As per statute and rule, above-ground storage projects that include these provisions receive preference for funding over other storage projects.

N/A

ATTACHMENT 1:
SITE MAP



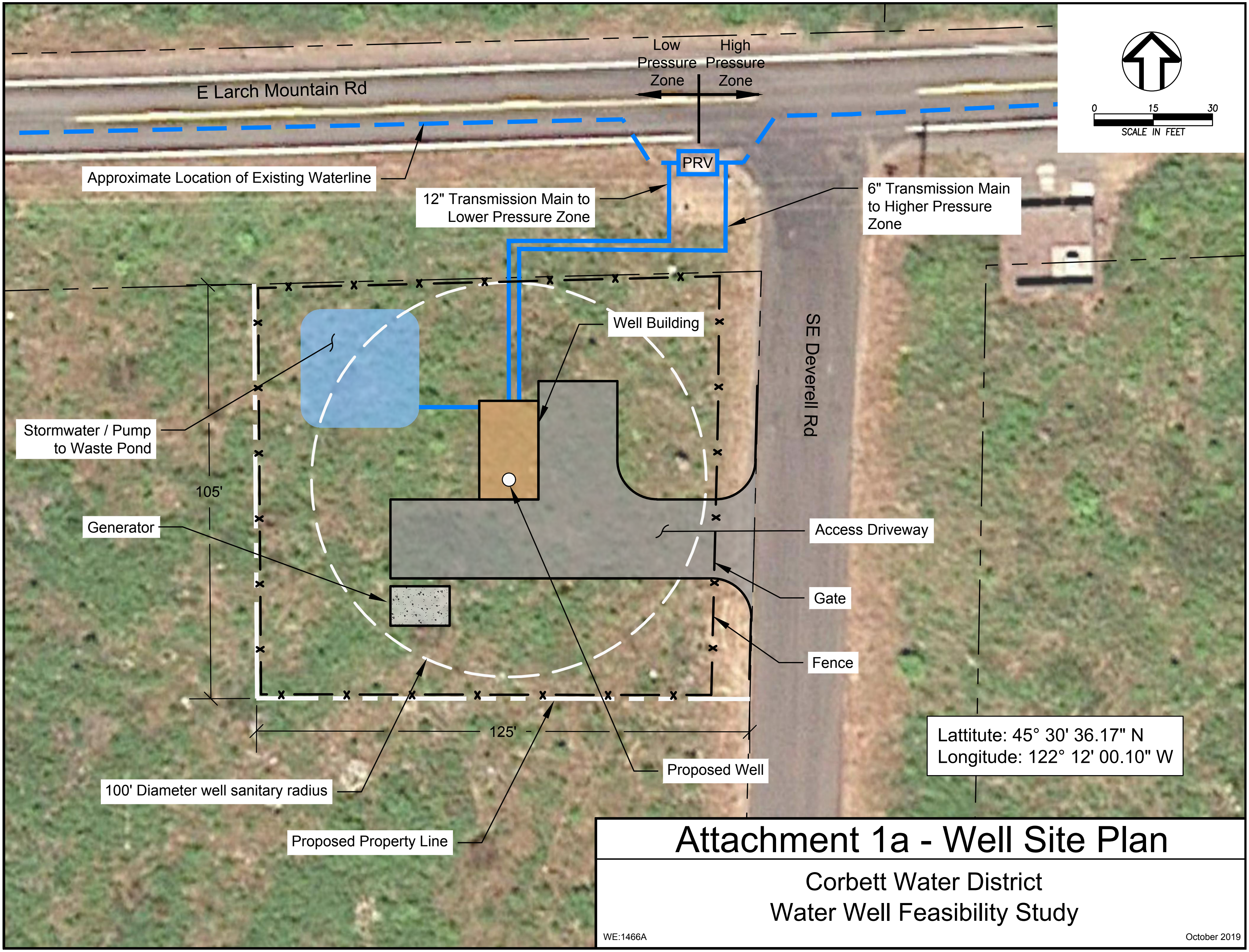
Attachment 1 - Vicinity Map

Corbett Water District
Water Well Feasibility Study

WE:1466A

October 2019

P:\14\1466A Corbett Wtr Well Feasibility Study\500 DWG\505 Exhibits\Vicinity Map.dwg, 11/1/2019 2:16:21 PM, Chad Kays



Attachment 1a - Well Site Plan

Corbett Water District
Water Well Feasibility Study

WE:1466A

October 2019

P:\14\1466A Corbett Wtr Well Feasibility Study\500 DWG\505 Exhibits\Preliminary Well House Layout.dwg, 11/1/2019 2:17:20 PM, Chad Kays

ATTACHMENT 2:
SIGNED LANDOWNER AGREEMENT FORM

OREGON
WATER RESOURCES
DEPARTMENT

Feasibility Study Grants

Landowner Agreement

Instructions to Applicants: Work with landowners to complete this form for all properties accessed for the study or on which the proposed study would occur. Submit this completed form as part of your grant application. For questions contact WRD_DL_feasibilitystudygrants@oregon.gov.

Project and Applicant Information

Project Name: Gordon Creek ASR Feasibility Study

Funding Applicant: Corbett Water District

Co-Applicant (if applicable):

Funding Applicant Contact Information:
Name: Jeff Busto
Phone Number: 503-695-2284
Email Address: cwdjeff@gmail.com

Co-Applicant Contact Information:
Name:
Phone Number:
Email Address:

Landowner Information – *NOTE: Please include ALL landowners listed on the deed .*

Landowner(s) Name: Jeff & Linda Hargens

Landowner's Authorized Representative: ____________________

Landowner(s) Contact Information (or Authorized Representative)
(required) Address: 43180 SE Deverell Rd. Corbett, OR 97019 (optional) Phone Number: 503-695-3337

(optional) Email Address: jhargens@nwearthmovers.com

Property Information

List each property owned by the above-mentioned Landowner(s) on which the study would occur:

County	Tax Map Number	Tax Lot Number
Multnomah		1S5E04-01500

Landowner Acknowledgement

1. Jeff and Linda Hargens is/are the legal owner(s) (the Landowner) of the above described property (the Property).
2. I am authorized to act on behalf of the Landowner.
3. I am aware of and agree to the above-mentioned proposed study and grant permission for the Applicant, and the Applicant's agents, to conduct the following activities on the Property. (List activities below)
   a. ASR Test Well
   b.
   c.
   d.
4. I certify that the above-mentioned information is true and accurate, I am aware of and agree to the proposed work, and I am authorized to sign as the Landowner or Authorized Representative.

Signature of Landowner(s) or Authorized Representative: ____________________

Date: 11/20/2019 Print Name: Jeff Hargens & Linda Hargens

ATTACHMENT 3:
DOCUMENTATION OF MATCHING FUNDS

Corbett Water District 36120 E. Historic Columbia River Hwy.
Corbett, OR 97019

Expenditures

GENERAL FUND - Capital Outlay

	Historical Data					Budget Next Fiscal Year 2019-2020		
	Actual		Adopted Budget		EXPENDITURE DESCRIPTION			
	Second Preceding Fiscal Year 16-17	First Preceding Fiscal Year 17-18	This Year Fiscal Year 18-19			**Proposed By Budget Officer**	**Approved Budget**	**Adopted Budget**
					CAPITAL OUTLAY			
1	-	-	10,500	1	Buildings	10,500	10,500	10,500
2	3,799	1,200	0	2	Filter Pond 1b	0	0	0
3	11,841	-	14,000	3	Fire Hydrants	14,000	10,000	10,000
4	-	-	50,000	4	Ground Water	250,000	250,000	250,000
5	4,336	12,636	350,000	5	Meters	-	-	-
6	44,144	-	45,000	6	Equipment and Vehicles	20,000	24,000	24,000
7	-	7,612	8,000	7	North Fork	8,000	8,000	8,000
8	2,688	-	0	8	PRV Stations	0	0	0
9	2,704	-	8,000	9	Reservoirs	20,000	20,000	20,000
10	496	-	0	10	South Fork (ODFW)	0	0	0
11	8,601	-	20,000	11	System Improvement	20,000	20,000	20,000
12	-	-	9,700	12	Toilet Rebates - U.P. Grant	9,700	9,700	9,700
13	9,811	3,756	10,000	13	Treatment Plant	10,000	10,000	10,000
14	2,844	-	21,500	14	Treatment Plant Computer System	-	-	-
15	4,466	-	0	15	Audit Adjustment capital outlay	0	0	0
16	**95,730**	**25,204**	**546,700**	16	**TOTAL CAPITAL OUTLAY**	**362,200**	**362,200**	**362,200**
17				17				
18	**0**	**-**	**187,200**	18	**OPERATING CONTINGENCY**	**180,000**	**180,000**	**180,001**
19	346,161	289,165	471,079	19	Total Expenditures Personnel Services (pg 2)	**475,783**	**475,783**	**475,784**
20	158,936	160,897	211,765	20	Total Expenditures Materials & Services (pg3)	**235,865**	**235,865**	**235,865**
21	95,730	25,204	546,700	21	Total Expenditures Capital Outlay (pg 4)	**362,200**	**362,200**	**362,200**
22	138,458	138,456	138,458	22	Total Expenditures Debt Service (pg 5)	**138,458**	**138,458**	**138,458**
23				23				
24	**739,285**	**613,722**	**1,555,202**	24	**TOTAL EXPENDITURES** (line 18+19+20+21+22)	**1,392,306**	**1,392,306**	**1,392,306**
25	909,867	1,136,596	190,166	25	Unappropriated ending fund balance	112,729	112,729	112,729
26	**1,649,152**	**1,750,318**	**1,745,368**	26	**TOTALS** (must equal Pg 1 Total Resources)	**1,505,035**	**1,505,035**	**1,505,035**

EXPLANATION OF LINE ITEM: The District Feasibility study and ten year plan include research into an additional water source to supplement our current supply. Further study of a well and permit process were started in FY2018-2019. This process will continue in 2019-2020 as well as pursuing grants and loans for partial funding of the project. Moving forward with an additional water source is a priority for the District.

ATTACHMENT 4:
DESCRIPTION OF APPROACH TO ADDRESS STORAGE-SPECIFIC STUDY REQUIREMENTS

STORAGE-SPECIFIC STUDY APPROACH

Gordon Creek is a tributary stream to the Sandy River, which supports sensitive, threatened or endangered fish species. Since the project would divert water from Gordon Creek it triggers the criteria for providing storage-specific study requirements.

The purpose of providing the storage-specific study requirements includes:

- To ensure that construction of the water storage project will not harm ecological or environmental resources
- To identify opportunities to mitigate possible environmental harm
- To confirm that the project is compatible with future Corbett Water District projects and will serve the long-term water needs of the community.

APPROACH:

The approach to providing the Storage-Specific Study will address the following requirements:

- Provide an Analysis of Ecological Flows, including an assessment of the impact that diverting flows has on bypass, optimum peak, and flushing flows.
- Provide a Comparative Analyses of Alternative Means of Supplying Water, including development of a list of alternative means of supplying water and providing a comparison of the alternative means of supplying water with the proposed ASR project.
- Provide an Analysis of Environmental Harm or Impact. A Cultural Resource Survey and an Environmental Review have already been prepared for the project (Task 1). These studies indicate that no environmental harm and no affects to cultural resources will result from construction of the project. (See Exhibits 'C' and 'D'.) The results of these studies will be included in the report.
- Provide an evaluation of Need and Ability to Augment Instream Flows. This will include:
    - An analysis will be provided to determine the need to augment instream flows to conserve, maintain and enhance aquatic life and any other ecological values. This will include summaries of water available in the basin and streamflow that is legally protected by existing instream water rights or scenic waterways within the stream reach of interest or downstream of the project area. The impact of the proposed storage project on these items (i.e., water availability and by-pass, optimum peak, flushing, and other ecological flows) will be evaluated and the need to augment instream flows to help meet ecological flows will be evaluated.
    - An analysis will be provided for the feasibility of instream flow augmentation to Gordon Creek from the project. The study analyses will include a hydrologic analysis of the area above the project, an analysis of the project's storage capabilities throughout the year, and an evaluation of the feasibility of if/how the project can operate to augment instream flows.
- Provide an Analysis Related to Municipal Use. The Corbett Water District is a municipal water supply and this special study requirement applies to this project.
    - An evaluation of future local and regional water demand will be provided. This will include an analysis of existing data/reports of estimated municipal water demand, including the adopted Water Master Plan, and how the project would impact other nearby communities.

  - The relationship of the proposed storage project to existing and planned infrastructure projects will be studied. The study will review the District's CIP and the Water Master Plan and discuss strategies to address water and infrastructure needs.

Qualified personnel:

Shane Latimer, PhD CSE, SCS Engineers: Dr. Latimer is an environmental planner, ecologist, and toxicologist with over 30 years of experience in environmental assessment, planning, permitting, and implementation. His specialty is developing projects that challenge the interface between the built and natural environment, including municipal drinking water facilities. These projects often require careful assessments of alternatives, impacts, and opportunities to successfully navigate the applicable public regulatory processes (e.g., NEPA, local land use, etc.) while ensuring environmental integrity. Dr. Latimer has a thorough understanding of engineering concepts and practices and is adept at working collaboratively with engineers and other professionals to ensure an optimum balance between environmental and engineering constraints. A main area of focus of Dr. Latimer's work during the last 25 years has been planning, permitting, and implementation of large projects that require substantial compensatory mitigation of wetlands and waters, as well as stand-alone ecological restoration projects. Many of these projects typically include significant issues related to species listed under the Endangered Species Act (e.g., salmonid fish), fish passage, floodplains, riparian zones, stream flows, stormwater treatment, water rights, and ecological integrity, often in the context of water use.

Tim Shell, PE, Senior Engineer, Wallis Engineering: Mr. Shell has over 30 years' experience in the design and construction of municipal water supply systems, including roles as both a consulting engineer and a public works director. Mr. Shell has been responsible for overseeing the development and implementation of water master plans for various municipalities and has been working with the Corbett Water District on this project for over a year.

ATTACHMENT 5:
LETTERS OF SUPPORT

CORBETT
SINCE 1949
FIRE DISTRICT No. 14

October 22, 2019

Oregon Water Resources Department
Attention: Grant Program Coordinator
725 Summer Street NE, Suite A
Salem, OR 97301

RE: SE Deverell Rd. Aquifer Storage and Recovery (ASR) Feasibility Study Grant 2019

Dear Grant Program Coordinator:

Water service from the Corbett Water District (CWD) is critical to Corbett Fire District #14. CWD has installed and maintains 84 fire hydrants for our use in emergency firefighting in Springdale and Corbett in the Columbia River Gorge National Scenic Area. These hydrants are vital to Corbett Fire District #14 and the emergency services we provide in the National Scenic Area to homeowners, visitors, Oregon State Parks and the US Forest Service.

We would like to convey our full support of the Corbett Water District's application for an Aquifer Storage and Recovery Feasibility Study Grant. The Corbett Water District currently supplies water by a single surface water source in Gordon Creek. This supply of surface water is vulnerable to natural disasters, such as the 2017 Eagle Creek Fire and meeting customer water usage demands. The Aquifer Storage and Recovery and deep well will provide our community with a much-needed additional water source. The additional water source will help ensure our strong, healthy fire and disaster response capability.

Sincerely,

Dave Flood

Fire Chief
Corbett Fire District #14

Corbett Fire District #14
PO Box 1
Corbett, OR 97019

Phone: 503-695-2272 Backyard Burning: 503-695-2225 FAX: 503-662-6310

Website: www.corbettfire.com

Randy Trani
Superintendent
Robin Lindeen-Blakeley
Deputy Clerk

35800 E. Historic Columbia River Highway
Corbett, Oregon 97019-9629
Administration Office: 503-261-4200
Grade School: 503-261-4236
Middle/High School: 503-261-4226
CAPS: 503-261-4269
Fax: 503-261-3641

Corbett School District
No. 39

October 23, 2019

Oregon Water Resources Department

Attention: Grant Program Coordinator

725 Summer Street NE, Suite A

Salem, OR 97301

RE: SE Deverell Rd. Aquifer Storage and Recovery (ASR) Feasibility Study Grant Application 2019

Dear Grant Program Coordinator:

The Corbett School District would like to convey our support for the Corbett Water District's SE Deverell Road Aquifer Storage and Recovery Feasibility Study Grant.

The Corbett Water District currently supplies water by a single surface water source in Gordon Creek. This supply of surface water is vulnerable to natural disasters, such as the 2017 Eagle Creek Fire and meeting increasing customer water usage demands. The Aquifer Storage and Recovery and deep well will provide Corbett Water District with a much needed additional water source. The additional water source will ensure water for the Corbett community and less demand on the stream during the lower stream flow in the summer months.

We highly recommend that you select the Corbett Water District for an Aquifer Storage and Recovery Feasibility Study Grant.

Sincerely,

Randy Trani Ed. D.

Superintendent

Corbett School District

Oregon

Kate Brown, Governor

Parks and Recreation Department
725 Summer St. NE, Suite C
Salem, OR 97301-1271
(503) 986-0980
Fax (503) 986-0794
www.oregonstateparks.org

October 23rd 2019
Oregon Water Resources Department
Attention: Grant Program Coordinator
725 Summer Street NE, Suite A
Salem, OR 97301
RE: SE Deverell Rd. Aquifer Storage and Recovery (ASR) Feasibility Study Grant Application 2019

Dear Grant Program Coordinator:

The Corbett Water District (CWD) is an essential partner of the Oregon State Parks located in the Columbia River Gorge National Scenic Area and along the Historic Columbia Highway. Our mission is to provide and protect outstanding natural, scenic, cultural, historic and recreational sites for the enjoyment and education of present and future generations.

The CWD helps us meet that mission at four very popular sites that are all open year round. The Dabney State Recreation Area, of nearly 135 acres is located right off the Historic Columbia River Highway and serves approximately 201,806 annually. At 7.26 acres, the Portland Women's Forum State Scenic Viewpoint is strategically located with phenomenal views of the Gorge and has an annual attendance of 383,794. The Crown Pont Scenic Corridor is comprised of 305.75 acres to include Vista House, listed in the National Register of Historic Places, provides outstanding views of the Gorge and enjoys an annual attendance of 584,832.

Last, but not least is the Rooster Rock State Park located along the Columbia River in the National Scenic Area includes 872.91 acres and serves 557,788 annually. This park is a Registered National Heritage site and also serves as a location for an Oregon State Park ranger facility.

The Corbett Water District provides very responsive and effective water service and support to all these locations comprising over 1300 acres. Their service is essential to our maintenance, operations, fire protection and all the visitors to these parks. We are very fortunate to have CWD on our team. We strive to serve our visitors well and protect and sustain the natural resources and environment of our recreation areas and parks. CWD has always been instrumental in our ability to meet those objectives. We highly recommend that you select the Corbett Water District for an Aquifer Storage and Recovery Feasibility Study Grant.

Sincerely,

Glenn Littrell

Glenn Littrell Park
Ranger Supervisor
West Gorge Management unit

ATTACHMENT 6:
PRELIMINARY ENGINEERING REPORT

Corbett Water District

Corbett, OR

WATER SYSTEM IMPROVEMENTS

Preliminary Engineering Report for USDA Rural Development

Final **Draft** March 2019

wallis
engineering

WE #1466

TABLE OF CONTENTS

EXHIBITS

Exhibit A – Vicinity Map

Exhibit B – Site Plan

Exhibit C – Corbett Water District Budget

Exhibit D – New Groundwater Supply Feasibility Study (SCS Engineers 2019)

Exhibit E – Hydrogeologic Study, Corbett Water District (Mark Yinger Associates, January 2016

Exhibit F – Cost Estimates

Exhibit G – Project Schedule

INTRODUCTION

The Corbett Water District (District) is currently obtains drinking water from a single surface water source. In recent years, this water source has been shown to be vulnerable to wildfires and variability in flow rates. The District is proposing to construct a new groundwater well to supplement and provide redundancy to its existing surface water source. Preliminary information has indicated that obtaining water rights from the Columbia River Basalts aquifer and development of a water supply well with a capacity of 500 to 1,000 gallons per minute (gpm) may be a viable option.

The District has identified a potential site for the proposed well that is located approximately 1 mile west of the existing water treatment facility, at the intersection of East Larch Mountain Road and Southeast Deverell Road. The proposed location for the well is on privately owned property. The parcel is zoned CFU-4 and appears to have been recently logged.

The purpose of this report is to summarize the proposed well project, and to satisfy the requirements for preparation of a Preliminary Engineering Report for the USDA Rural Utilities Service for the Water and Waste Disposal program, as outlined in USDA Bulletin 1780-2, a first step to applying for funding for the proposed improvements summarized in this report.

1. PROJECT PLANNING

The project planning area is shown on the vicinity map included as Exhibit A, and described in detail below.

a) Location

The District is located in Multnomah County, Oregon at the west end of the Columbia River Gorge. Corbett is the principle community served by the District. The Sandy River borders the District on the west and southwest. The Columbia River borders on the north, and the area known as Larch Mountain borders on the east. The Bull Run watershed is located 15 miles southeast of Corbett. The District’s service area is approximately 8.5 miles long, east to west, and approximately 3.2 miles wide, north to south. The elevation ranges from approximately 15 feet to 1,300 feet above mean sea level. The drainages are generally deeply incised and flow to the west and southwest to discharge into the Sandy River.

b) Environmental Resources Present

The proposed well site is located on property that was previously clearcut. There are no known environmental resources present in the project planning area that will affect the design of the project. Water rights in the Sandy River basin have been completely allocated. However, this project proposes to obtain water rights from the deeper Columbia River Aquifer, which is not currently limited by water rights.

c) Growth Areas and Population Trends

Currently the districts serves approximately 1083 customers, a population of approximately 3,080. According to the *Corbett Water Districts Water Master Plan* (February 2003, Lee Engineering), a slight or no increase in population can be expected for the next 25 years.

d) Community Engagement

The District Board of Commissioners meets monthly. Discussions of project planning will occur at these meetings, which are open to the public. In addition, project open houses will be held to further inform the District residents of the proposed project and obtain public feedback.

2. EXISTING FACILITIES

The District currently produces drinking water from a water treatment plant (WTP), which treats water from the North Fork and South Fork of Gordon Creek. The WTP includes three slow sand filters, a covered clear well for chlorine disinfection, and a one million-gallon reservoir. The plant is completely manually operated; thus the flow rate has to be manually adjusted to meet the demand of the District. The WTP is located at the high point in the District's service area and feeds the distribution network by gravity. The distribution system includes 12 pressure reducing valves to separate pressure zones.

Existing facilities at the proposed well site consist of a 10-inch steel water main in Larch Mountain Road. A pressure reducing valve just west of Deverell Road divides two pressure zones. The upper pressure zone serves several residences to the east of Deverell Road, and the lower pressure zone serves the remainder of the District.

a) Location Map

A location map is included as Figure 1 in Appendix A.

b) History

The slow sand filters at the WTP were constructed in the 1980's. One of the filter ponds was upgraded in 2004 to a concrete basin filter, along with the construction of the reservoir at the WTP. Most of the transmission mains and reservoirs were constructed in the 1950's and 1960's. Reservoir #6 is an above ground 1 MG steel tank constructed at the Water Treatment Plant in 2004. Reservoir #1 has been abandoned and disconnected from the system. Reservoir #2 was completely restored in 2010 including new controls, piping and epoxy coating inside and out. Reservoir #'s 3, 4, 5, and 6 were inspected during the 2018 fiscal year. Reservoir #3 was noted as needing an interior overhaul. All other reservoirs passed inspection. There have been no major equipment failures or violations of regulatory requirements. Most recently the District received a 100% rating from OSHA and passed the Oregon Health Authority sanitary survey with a few small regulatory issues to correct that were addressed and corrected without any fines or citations.

c) Condition of Existing Facilities

In 2003 Lee Engineering, Inc. prepared an Water Master Plan Update, which included a system-wide evaluation of all water facilities and a list of improvement projects was recommended. Since 2003, the District has made various improvements to the facilities. The main focus of this PER is the addition of a back-up well to provide a redundant water source for additional water during the summer months.

The condition of the existing facilities can be broken down into a) treatment plant, b) transmission mains and distribution system, c) storage reservoirs and d) District facilities. Although the current water plan (February 2003) does include a list if capital facilities improvements, expenditures have recently been related to maintenance and upgrading the water meters to radio read, and no capital improvements have been constructed in the last two years. All facilities are suitable for continued use and there have been no violations of applicable laws. The water system is entirely gravity fed and very efficient energy-wise.

a) Slow Sand Filter Treatment plant: The treatment plant operates sufficiently. The major issue with it is that it is totally manual operation and is labor-intensive. Future improvements are planned around automated operation.

b) Transmission and Distribution Systems: The overall condition of the existing transmission mains is "fair". Portions of the transmission lines are constructed of steel pipe and 50+ years old. The significant issue is internal corrosion of the steel pipe that restricts flow capacity. Future improvements include relining of some of these mains.

The overall condition of the distribution system is rated as "fair". Similar to the transmission mains, the main issue with the distribution system is that it is constructed primarily with steel pipe, which is susceptible to corrosion. Much of the pipeline throughout the District was constructed in the 1950's and 1960's and is reaching the end of its serviceable life.

c) Storage reservoirs: Reservoir #1 has been abandoned and is no longer connected to the system Reservoir #2 was completely rebuilt in 2010 and is in good condition. Reservoir #'s 3, 4, 5, and 6 were inspected during the 2018 fiscal year. Reservoir #3 was noted as needing an interior overhaul. All other reservoirs passed inspection.

d) District facilities: The existing facilities include District office facilities, and were constructed in the early 1950's. The 2003 Water Plan recommends that the District build a new facility due to an assessment that the current facilities are inefficient for today's level of use.

d) Financial Status of Existing Facilities

The District's current budget is included as Exhibit C.

e) Water/Energy/Waste Audits

No water, energy, and/or waste audits have been conducted.

3. NEED FOR PROJECT

This project is needed in order to increase the reliability of the District's water supply, and to provide additional capacity during the summer months. The District currently obtains water from a single surface source. The recent Eagle Creek Fire burned within miles of the Gordon Creek watershed, threatening this source. In addition, in recent years the water supply has been increasingly variable during dry weather, and the maximum demand is approaching the supply capacity. There is also concern that in the future climate change will impact the reliability of the existing water source. Improving the redundancy and resiliency of the District's water supply is thus of paramount importance.

a) Health, Sanitation and Security

The need for this project is to provide a more reliable and resilient drinking water source for the District. The primary health concern is the possibility that the existing water supply could be depleted during dry periods or impacted by wildfires or other outside influences, leaving the District's customers with no readily available source of drinking water.

b) Aging Infrastructure

This project is needed in order to provide reliable uninterrupted water service to the constituents of the Corbett Water District.

c) Reasonable Growth

According to the *2003 Water Master Plan Update* (Lee Engineering), little to no growth is expected within the service area for the 20-year planning period. The proposed well will be sized at 500 gallons per minute (gpm) to provide redundancy to the existing water source. The system will be designed with provisions to allow for an upgrade to 1,000 gpm if additional capacity is needed in the future or if the existing water source from Gorden Creek is lost.

4. ALTERNATIVES CONSIDERED

The District has evaluated a number of alternatives to improve the resiliency of their water supply(see Exhibit XX). Two feasible alternatives are described in this report: the construction of a groundwater production well and the construction of an aquifer storage and recovery. Three alternatives were considered and dismissed:

No project: this would fail to provide a reliable drinking water source.

Expanding the current water source: this is not feasible due to limited water rights in the Sandy River basin.

Additional above ground storage: this option is not cost effective due to the large reservoir that would be required, and because it would not provide redundancy to the single water source.

The two feasible alternatives are described in detail below.

a) Description

Alternative 1 – Production Well at East Larch Mountain Road

Under this alternative, a groundwater well would be constructed at the upper elevations of the District to pump water from the deep Columbia River Basalt (CRB) Aquiferto connect into the existing system by gravity flow. The new well would be used only to supplement the system's capacity during summer months, or if there was a failure of the existing water source. Other options for groundwater sources and well locations were evaluated in the *New Groundwater Supply Feasibility Study by SCS Engineers* 2019 (Exhibit D) and the *Hydrogeologic Study, Corbett Water District by Mark Yinger Associates, January 2016* (Exhibit E). Other well locations lower in elevation, such as at existing reservoir sites, were found to be infeasible due to the high capital and operating cost of pumping water to higher pressure zones. Shallow groundwater sources were also found to be infeasible due to over-allocation of water rights.

According to the *New Groundwater Supply Feasibility Study*, the only feasible option for a groundwater supply well is a 1,000 to 1,300-foot deep well in the CRB aquifer, which is expected to yield the needed 500 – 1,000 gpm. A location for the proposed well was found at the intersection of East Larch Mountain Road and Deverell Road, about one mile west of the WTP. The production well would be constructed with an initial capacity of 500 gpm with an oversize casing for an ultimate capacity of 1,000 gpm.

Alternative 2 – Aquifer Storage and Recovery

This alternative consists of constructing an aquifer storage and recovery (ASR) well in the CRB aquifer. Excess capacity from the District's surface water source would be pumped into the well during wet weather months and extracted during dry weather months if the additional capacity is needed. This alternative could be implemented if the production well yield is inadequate. This alternative would require the same components as the production well, with additional valves and equipment necessary to inject water into the well.

b) Design Criteria

The proposed improvements will be designed in accordance with all applicable regulatory standards, including the Oregon well construction standards (OAR 690-200 through 690-240) and all 7 CFR 1780.57 requirements.

c) Map

A site plan of the proposed improvements is included as Exhibit B.

d) Environmental Impacts

No environmental impacts have been identified.

e) Land Requirements

Both alternatives require approximately 13,000 square feet of property for the well building, access driveway, backup generator, and pump to waste pond. This includes a 100-foot radius around the proposed well. The District currently does not own land in the vicinity of the proposed well, and will need to purchase land prior to the proposed improvements. The current land owner has indicated that they would be a willing seller.

f) Potential Construction Problems

No significant construction problems are anticipated for the project. However, geotechnical investigations will be conducted during design to reduce the risk of subsurface construction challenges.

g) Sustainability Considerations

i) Water and Energy Efficiency

There are no significant water and energy efficiency differences between alternatives. However, because the WTP is at a higher elevation than the well, energy recovery may be an option for the ASR alternative. Installing a turbine generator into the well casing will be considered during final design to recover energy from water flowing from the WTP to the well during aquifer recharge.

ii) Green Infrastructure.

There are no significant green infrastructure differences between the alternatives. A small amount of stormwater will be generated by development of the well site. Stormwater runoff will be routed to the pump-to-waste pond and either infiltrated or released into a conveyance ditch on East Larch Mountain Road, complying with all local stormwater regulations.

h) Cost Estimates

Preliminary capital cost estimates were prepared for both alternatives, and are included in Exhibit F and summarized below in Table 1. This estimate includes both construction and non-construction costs, and is in 2019 dollars (ENR Seattle CCI 12008.39).

Table 1 – Capital Cost

Alternative	Capital Cost
Production Well	$1,991,000
ASR Well	$2,183,000

Because operations and maintenance costs will be highly dependent upon how much water is extracted from or injected into the well, an O&M cost comparison of the two alternatives was not evaluated at this time. In general, the O&M costs of Alternative 2 will be higher than Alternative 1 due to the additional equipment used for water injection. However, total O&M costs for each alternative are not expected to be significant. In addition, when the well is used the water treatment plant use will decrease, offsetting some of the O&M costs.

5. SELECTION OF AN ALTERNATIVE

Because there are no significant non-monetary differences between alternatives, Alternative 1 is the preferred alternative due to its lower cost. However, if the well yield is inadequate, Alternative 2 can be pursued.

6. PROPOSED PROJECT (RECOMMENDED ALTERNATIVE)

The proposed project will be designed to provide a redundant water supply source for the District.

a) Preliminary Project Design

The preliminary project design is summarized below for each component. A preliminary site plan is included as Exhibit B.

i) Production Well

A new production well will be constructed to provide a new water source for the District's customers. The well pump will be sized to provide a flow rate of 500 gpm, which will require a 150 to 200 horsepower (hp) motor depending upon the depth to water. An equipment building will be constructed to house the mechanical and electrical equipment for the proposed well. This will include well discharge piping and valves, disinfection equipment, and the electrical and control panels. The equipment building will be approximately 15 by 25 feet, and include two rooms: a disinfection room and a mechanical and electrical room.

The well will connect to the existing water main in Larch Mountain Road. The proposed well location is at the boundary of two pressure zones. The upper pressure zone serves several houses, and the lower pressure zone feeds the remainder of the District. To minimize the total dynamic head of the well pump, the well will be connected to the lower pressure zone. A small booster pump will then be used to maintain pressure in the upper pressure zone. A variable speed pump will be provided so that the water supply can match the demand

A summary of the proposed well design criteria is shown below in Table 2.

Table 2 – Production Well Basis of Design

Design Item	Initial Design Value
Well Depth (bgs)	1400 ft
Water Level Depth (feet bgs)	800 ft
Pumping Rate (gpm)	500
Well Pump Motor Size (HP)	175

ii) *Site Improvements*

Site improvements will include an access driveway, fencing, and landscaping. A pump to waste storage pond would be required for the ASR alternative to reduce peak flow rates and prevent erosion of the drainage ditch ultimately receiving the flow.

iii) *Treatment*

Water treatment will include a sodium hypochlorite injection system. Additional treatment requirements, if any, will be determined after testing the water quality from the test well. Based on information from another nearby well in the CRB aquifier, additional treatment is not anticipated.

iv) *Electrical Service*

Three phase, 480 V electrical service will be required for the proposed well. Three phase power is available from PGE service lines along Larch Mountain Road. Sizing of the electrical service will be completed during final design when pumps are selected.

v) *Backup Power*

A diesel generator will provide a backup power supply. The generator will be sized to handle the full load of the well pump. Due to the remote location the generator will include a four-day fuel supply stored in a double contained tank.

b) Project Schedule

The design of the improvements is expected to commence in summer 2019. Depending on availability of grants and loans, construction is anticipated to begin in 2019/2020, and be completed by spring of 2021. See Exhibit G.

c) Permit Requirements

The District is currently pursuing a water rights permit for the proposed groundwater well.

Multnomah County permits will also be required. A Multnomah County Land Use Compatibility Determination will be required for the well. A Conditional Use Permit will be required to allow a lot size less than the minimum 80-acre size allowed in the CFU zoning. Creation of a new parcel of property for the well site will be administered as a Category 3 Partition. Site Plan Approval and building permits will be required prior to construction.

d) Sustainability Considerations

i) Water and Energy Efficiency

Well pumps will be designed with variable frequency drives to optimize energy consumption and to match the water supply with demand. Well and water treatment plant building will comply with the current energy code, which addresses energy efficiency goals.

ii) Green Infrastructure

Site improvements will be designed to limit impervious areas and maximize onsite infiltration of stormwater. This project will not increase the total impervious by more than 5,000 square feet compared to existing conditions.

e) Total Project Cost Estimate

Preliminary capital cost estimates were prepared including both construction and non-construction costs, shown below in Exhibit XX. This cost is in 2019 dollars (ENR Seattle CCI 12008.39). A detailed cost breakdown is included in Exhibit XX.

f) Annual Operating Budget

The annual operation and maintenance costs (O&M) for the District will increase slightly as a result of the proposed improvements. The current staff will be sufficient to operate and maintain the additional improved facilities.

Annual O&M costs will be highly dependent upon how much the District utilizes the proposed backup well. For purposes of developing an annual operating budget, it is assumed that the backup well will provide 25 MG per year, which is equivalent 10% of the District's overall annual water consumption of 250 MG.

i. Income: Income will be generated primarily from the sale of water.

ii. Annual O&M Costs:

Electrical power	$7,500
Chemical treatment	$1,000
Small Equipment Replacement	$5,000/year
Total Annual O&M Cost:	$13,500

Cost Assumptions:

1) Well will provide 25 MG of water annually, which is approximately 10% of the annual water use.
2) Electrical power costs based on $.06 per kWh.
3) Chemical treatment includes chlorine treatment at $.03 per 750 gal.
4) Operations and maintenance can be provided with existing District personnel.

iii. Debt Repayments:

iv. Reserves:

Debt Service Reserve:

Short-Lived Asset Reserve:

7. CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the Corbett Water District move forward with the detailed engineering of the proposed facilities, while simultaneously identifying a funding source for their construction and also satisfying all regulatory requirements needed for construction.

EXHIBIT A – VICINITY MAP

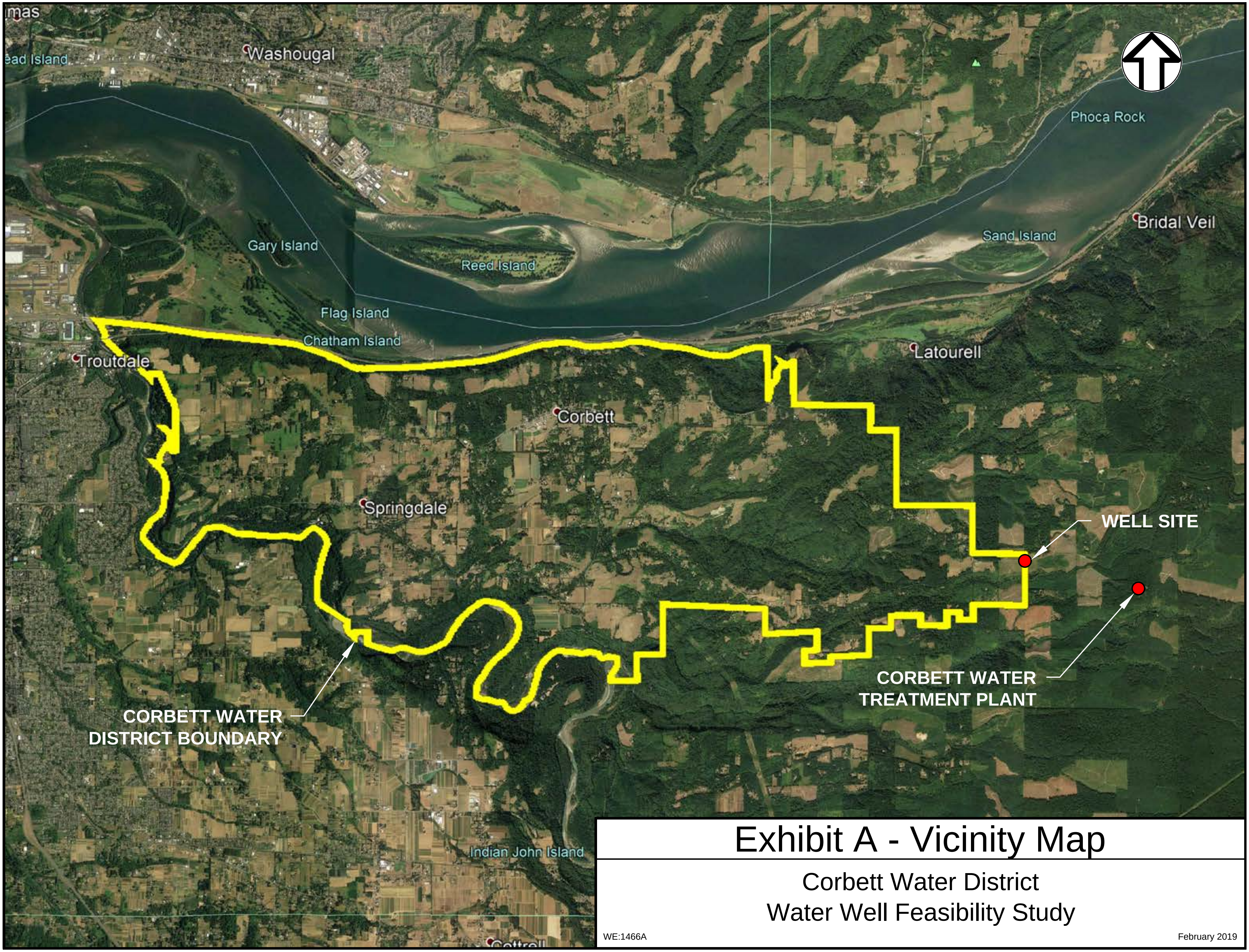


Exhibit A - Vicinity Map

Corbett Water District
Water Well Feasibility Study

WE:1466A

February 2019

P:\14\1466A Corbett Wtr Well Feasibility Study\500 DWG\505 Exhibits\Vicinity Map.dwg, 2/19/2019 1:24:02 PM, Tomalynn Silva

EXHIBIT B – SITE PLAN

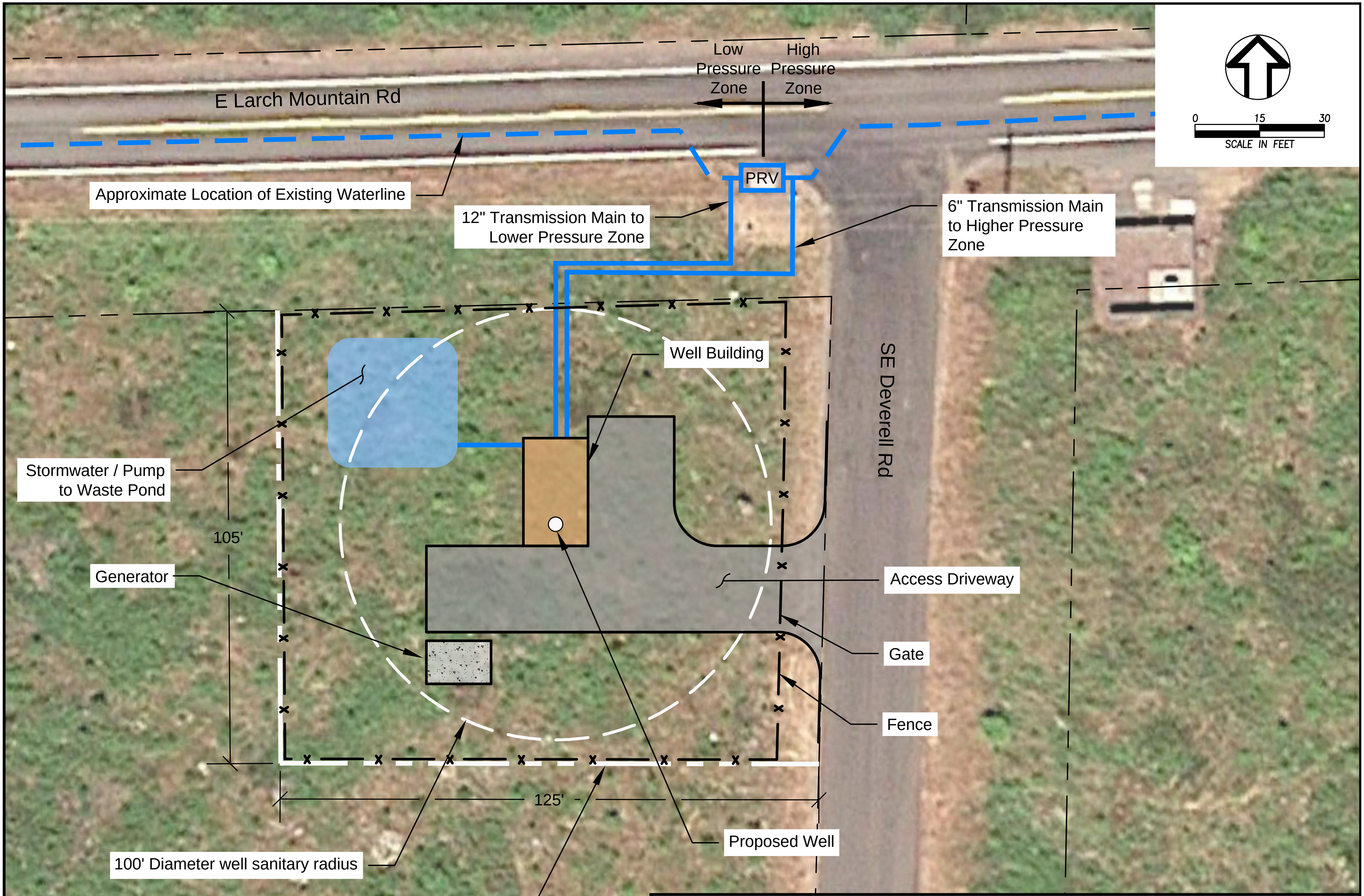


Exhibit B - Well Site Plan

Corbett Water District
Water Well Feasibility Study

WE:1466A

February 2019

P:\14\1466A Corbett Wtr Well Feasibility Study\500 DWG\505 Exhibits\Preliminary Well House Layout.dwg, 3/18/2019 2:48:26 PM, Chad Kays

EXHIBIT F – COST ESTIMATE

WATER WELL FEASIBILITY STUDY
CORBETT WATER DISTRICT
Exhibit E - Preliminary Cost Estimate
Alternative 1- 500 gpm Production Well

Prepared by Wallis Engineering February, 2019
WE# 1466A

CONCEPTUAL LEVEL COST ESTIMATE

ITEM NO.	BID ITEM DESCRIPTION	QTY.	UNIT	UNIT COST	TOTAL COST
1	Well Construction, Development and Testing (16" Casing)	1	LS	$ 610,000	$ 610,000
2	Well Building and Site Improvements	1	LS	$ 777,000	$ 777,000
	Mobilization			*$ 70,000*	
	Well Pump and Appurtenances (200 HP)			*$ 278,000*	
	Well Building			*$ 85,000*	
	Site Improvements			*$ 25,000*	
	Valves and Piping			*$ 36,000*	
	Electrical and Control Equipment			*$ 87,000*	
	Electrical Service			*$ 23,000*	
	Backup Generator			*$ 108,000*	
	Chlorine Injection System			*$ 16,000*	
	Booster Pump			*$ 30,000*	
	Yard Piping and Connection to Existing Water Main			$ 19,000.00	
				Construction Subtotal	$ 1,387,000
				Design Engineering (12%)	$ 166,000
				Construction Engineering (8%)	$ 111,000
				Water Rights/Permitting	$ 15,000
				Environmental Studies	$ 20,000
				Property Acquisition	$ 5,000
				Reporting	$ 10,000
				Contingency (20%)	$ 277,000
				Grand Total	**$ 1,991,000**

Notes:

1 Costs are 2019 pricing.

2 Assumes a 500 gpm production well with oversized casing for future upgrade to 1,000 gpm.

3 From PumpTech: $174k for pump and column pipe plus $54k for cable

4 Romtec prefab CMU bldg, 24'x22' - $60k

WATER WELL FEASIBILITY STUDY
CORBETT WATER DISTRICT
Exhibit E - Preliminary Cost Estimate
Alternative 2- 500 gpm Production Well with Aquifer Storage and Recovery Well

Prepared by Wallis Engineering February, 2019
WE# 1466A

CONCEPTUAL LEVEL COST ESTIMATE

ITEM NO.	BID ITEM DESCRIPTION	QTY.	UNIT	UNIT COST	TOTAL COST
1	Well Construction, Development and Testing (16" Casing)	1	LS	$ 610,000	$ 610,000
2	Well Building and Site Improvements	1	LS	$ 913,000	$ 913,000
	Mobilization			*$ 80,000*	
	Well Pump and Appurtenances (200 HP)			*$ 278,000*	
	Well Building			*$ 85,000*	
	Site Improvements			*$ 25,000*	
	Valves and Piping			*$ 42,000*	
	Downhole Control Valve			*$ 115,000*	
	Electrical and Control Equipment			*$ 92,000*	
	Electrical Service			*$ 23,000*	
	Backup Generator			*$ 108,000*	
	Chlorine Injection System			*$ 16,000*	
	Booster Pump			*$ 30,000*	
	Yard Piping and Connection to Existing Water Main			$ 19,000.00	
				Construction Subtotal	$ 1,523,000
				Design Engineering (12%)	$ 183,000
				Construction Engineering (8%)	$ 122,000
				Water Rights/Permitting	$ 15,000
				Environmental Studies	$ 20,000
				Property Acquisition	$ 5,000
				Reporting	$ 10,000
				Contingency (20%)	$ 305,000
				Grand Total	**$ 2,183,000**

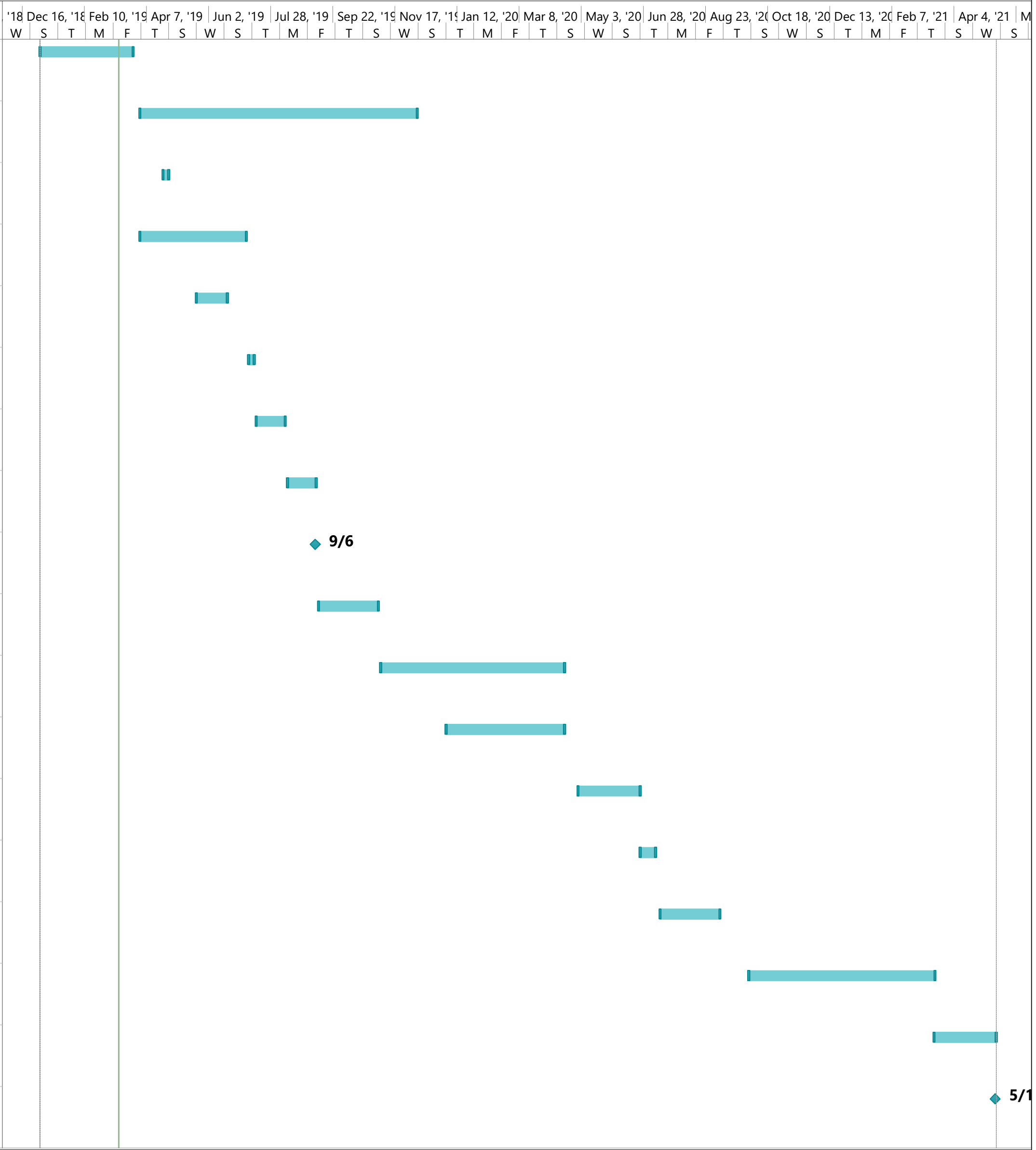
Notes:

1	Costs are 2019 pricing.
2	Assumes a 500 gpm production well with oversized casing for future upgrade to 1,000 gpm.
3	From PumpTech: $174k for pump and column pipe plus $54k for cable
4	Romtec prefab CMU bldg, 24'x22' - $60k
5	Pump-to-waste pond will be permitted to drain to ditch on Larch Mountain Rd.

EXHIBIT G - PROJECT SCHEDULE

Corbett Water District
New Water Well
Preliminary Project Schedule
March, 2019

ID	ℹ	Task Mode	Task Name	Duration	Start	Finish
2		📌	Prelim Engineering Report	3 mons	Tue 1/1/19	Mon 3/25/19
3		📌	Water Rights/Permits	9 mons	Mon 4/1/19	Fri 12/6/19
4		📌	County Pre-App Meeting	1 wk	Mon 4/22/19	Fri 4/26/19
5		📌	Project Environmental Review/Report, Section 106 Tribal Consultations	3.5 mons	Mon 4/1/19	Fri 7/5/19
7		📌	Prepare Funding Applications	1 mon	Wed 5/22/19	Tue 6/18/19
8		📌	Submit PER, ER, Funding App's to USDA	1 wk	Mon 7/8/19	Fri 7/12/19
9		📌	USDA Review	1 mon	Mon 7/15/19	Fri 8/9/19
10		📌	Respond to PER & ER Comments, Resubmit, Final Review	1 mon	Mon 8/12/19	Fri 9/6/19
11		📌	USDA Letter of Funding Eligibility	0 mons	Fri 9/6/19	Fri 9/6/19
12		📌	USDA Letter of Funding Conditions	2 mons	Mon 9/9/19	Fri 11/1/19
13		📌	Project Design, Preparation of Contract Documents	6 mons	Mon 11/4/19	Fri 4/17/20
14		📌	County Land Use/Building Permits	3.85 mons	Thu 1/2/20	Fri 4/17/20
16		📌	Project Advertisement/Bidding	2 mons	Thu 4/30/20	Wed 6/24/20
17		📌	USDA Loan Agreement	10 days	Thu 6/25/20	Wed 7/8/20
18		📌	Schedule I: Well Construction/Development, Flow Test	2 mons	Mon 7/13/20	Fri 9/4/20
19		📌	Schedule II: Mechanical, Building, Site Development	6 mons	Thu 10/1/20	Wed 3/17/21
20		📌	Project Closeout	2 mons	Wed 3/17/21	Tue 5/11/21
21		📌	Project Complete	0 days	Tue 5/11/21	Tue 5/11/21



Project: Corbett Well Prelim Pro
Date: Wed 3/13/19

Task	▬	Project Summary	⌐¬	Manual Task	▬	Start-only	[	Deadline	⇩
Split	┈┈┈	Inactive Task	▭	Duration-only	▬	Finish-only	]	Progress	─
Milestone	◆	Inactive Milestone	◇	Manual Summary Rollup	▬	External Tasks	▬	Manual Progress	─
Summary	⌐¬	Inactive Summary	⌐¬	Manual Summary	⌐¬	External Milestone	◇		

ATTACHMENT 7:
PRELIMINARY FEASIBILITY ASSESSMENT

SCS ENGINEERS Environmental Consultants & Contractors

February 14, 2019
File No. 04218051.00

DRAFT MEMORANDUM

TO: Jeff Busto, District Manager Corbett Water District

CC: Tim Shell, PE, Wallis Engineering
Jack Wallis, PE, Wallis Engineering

FROM: Christopher Augustine, RG, CWRE, SCS Engineers
David Lamadrid, RG, SCS Engineers

SUBJECT: New Groundwater Supply Feasibility Study

Corbett Water District (CWD) desires to add a groundwater source to introduce redundancy and improve flexibility within its existing water supply system that currently relies solely on surface water from the South Fork of Gordon Creek in the North Fork Gordon Creek Municipal Water Management Area (Water Management Area). This surface water source currently meets municipal water supply demands, but the source is sensitive to land management practices, forest fire hazards, and climate patterns that threaten its ability to meet current and future demand. Recent statewide drought conditions have reinforced the sensitivity of the surface water source and the need for additional source capacity to prevent interruption or reduction of water delivery to CWD customers.

Additional surface water is not available from Gordon Creek, as its remaining flow is protected as an instream water right. While developing additional storage or service connections with neighboring water providers may be alternatives, a new groundwater supply is the more economical alternative source for municipal drinking water to provide redundancy for the CWD system. The feasibility for developing a new groundwater supply was previously investigated and presented in *Hydrogeologic Study Corbett Water District*, Mark Yinger and Associates, 2016. That study looked at multiple locations within the CWD system, and well construction options for groundwater sources from the various aquifers within the CWD service area.

The primary alternatives to develop a new groundwater source identified in the 2016 study included:

1. Develop a new groundwater water supply well, or
2. Pursue Aquifer Storage and Recovery (ASR) using a new water supply well if water quality or other conditions limit native groundwater withdrawals to meet CWD municipal water supply needs. ASR would provide both additional system capacity and storage for CWD.

The conclusions of that study were that a new groundwater source would need to be located in the eastern portion of the CWD service area and the well would need to be constructed to limit the potential for groundwater pumping to effect surface water features; however, those conclusions were based on limited available data in the study area and preliminary conversations with the Oregon Water Resources Department (OWRD) regarding a new groundwater right permit. In 2018, the CWD revisited the 2016 study to determine if additional geologic or hydrogeologic data warranted further evaluation of a well in the upper portion of the CWD service area.

Review of additional geologic, hydrogeologic information and newly permitted water rights within the service area suggested that a new well was feasible, but would require it to be drilled and constructed to limit impacts to surface water.

This technical memorandum presents SCS Engineers' (SCS) investigation of the feasibility and associated costs for Corbett Water District (CWD) with developing a new groundwater supply source for drinking water. The evaluation of the new groundwater supply source is presented in the following sections.

1. Siting Evaluation
2. Conceptual Well Design
3. Regulatory Pathway and Framework

A detailed description of each task is presented below.

1 SITING EVALUATION

The primary objective of the siting evaluation was to evaluate the location of a new water supply well within the CWD distribution system and service area. Previous discussions regarding the preferred location identified that a feasible location would need to meet the following requirements:

- Located in the upper CWD service area near the water treatment plant
- Be located as far as practical from surface water drainages
- Allow CWD to establish ownership or long term easements of the property
- Meet regulatory requirements under OAR 333-061

Based on review of these requirements and available sites the preferred location was identified at the intersection of East Larch Mountain Road and SE Deverell Road (Figure 1). The site is located near the top of the CWD service area, which is a gravity fed water distribution system with a majority of its customers hydraulically below the proposed well location elevation in their system.

Site reconnaissance suggested that the site was suitable to meet all set back requirements of the OAR 333-061-0050(1) for a new drinking water supply well and those required under OAR 690 – 210 which include the following:

- 100 feet required ownership or easement around well
- 100 feet setback from sewage disposal, solid waste, etc.
- 50 feet setback from septic tanks and pipes
- 50 feet setback from concentrated feeding animal operations (CAFO)
- 500 feet setback from hazardous waste storage.

A site plan for the well and supporting infrastructure that meets the setback requirements was prepared by Wallis Engineering (2019).

2 CONCEPTUAL WELL DESIGN

This section presents a summary of the geologic and hydrogeologic description of the CWD Water Management Area and the target aquifer, the conceptual well design, and planning level cost estimates for drilling and testing.

Geology and Hydrogeology

The geology within the vicinity of the CWD service area is complex and significant geologic influences include the following:

- Ancestral Columbia River and Columbia River tributaries
- Boring lava eruptions
- Subsidence of the Portland Basin
- Missoula cataclysmic floods
- Eruption of the flood basalts of Columbia River Basalt Group (CRBG)
- Uplift and volcanism of the Cascade Range.

Figure 2 is a compilation geologic map, and Figures 3 and 4 are generalized geologic cross- sections presented in the 2016 study by Mark Yinger and Associates. The geologic map is based on a U.S. Geologic Survey map of the Washougal Quadrangle (Evarts, et. al, 2103) and a Washington Department of Natural Resources map of the Vancouver Quadrangle (Phillips, 1987). The following description of the geology generally proceeds from the oldest rocks to the youngest:

- Western Cascade Volcanics
- Columbia River Basalt Group (CRBG)
- Troutdale Formation
- High Cascade Volcanics and Boring Lava.

The geology and hydrogeology was described in detail in the previous study by Mark Yinger and Associates, 2016. Based on the interpretations in the previous investigation and subsequent review of additional geologic and hydrogeologic information not included in the 2016 study, the CRBG is the target aquifer for a new groundwater source for the CWD. The basement rocks of the Western Cascade Volcanics are not considered as a source or pertinent to the well design. A summary of the units that will need to be considered for the well design and drilling program are provided below.

Columbia River Basalt Group

The early to middle Miocene Grande Ronde Basalt flows of the CRBG overlie the rocks of the Western Cascades on an erosional unconformity. The CRBG consist of a sequence of multiple flood basalt flows that emanated from vents in eastern Washington, Oregon and Idaho. In the Portland Basin, the CRBG consists of the basalt flows from Grande Ronde Basalt and Wanapum Basalt. The Grande Ronde and Wanapum flows consists of up to 50 individual flood basalt flows ranging from in thickness from 40 to 100 feet (Conlon et al., 2005; Gannett and Caldwell, 1998). The CRBG are only exposed east of Corbett Station, on the lower portion of the steep slope that rises from the shore of the Columbia River. Where exposed they have an approximate total thickness of 1,200 feet above ground surface; however, based on available information from well logs and geologic reports in and around the Portland Basin, the CRBG has an approximate thickness of up to 2,200 feet (Conlon et al., 2005).

Numerous studies of CRBG aquifers have been conducted within the Columbia and Portland Basins to better understand their hydraulic characteristics and to develop a model of how various factors (e.g., CRBG flow physical characteristic/properties, tectonic features/properties, erosional features, climate, etc.) interact to create and govern the CRBG as a confined groundwater system. These studies have found that the CRBG hosts a series of confined aquifers collectively referred to as the "CRBG aquifer system." One of the overall significant findings of these studies is the general similarity of the hydrogeologic characteristics, properties, and behavior of the CRBG aquifers across this region.

It is widely agreed that within CRBG aquifers, given the typical distribution and physical characteristics of CRBG intraflow structures, groundwater primarily resides within the interflow zones. An interflow zone (Figure 5) is defined as the flow top of one flow and the flow bottom of the overlying flow (plus interbedded sediment). CRBG interflow zones are tabular, laterally extensive, bodies that have physical properties conducive to forming an aquifer. The properties of interbedded sediments can either enhance (e.g., sandstone and conglomerate) or inhibit (e.g., mudstone and paleosols) groundwater storage and movement within this zone. The undisturbed, laterally extensive, dense interiors of CRBG flows typically act as confining units and account for the confined behavior exhibited by most CRBG aquifers. In many areas around the Columbia Plateau, artesian (flowing) conditions within the CRBG aquifer system have been encountered, including in wells drilled by the City of Portland at the Bull Run Reservoirs (Appendix A).

Water supply wells completed in the CRBG are typically highly productive and provide yields of 1,500 gallons per minute (gpm) or more and are a regional groundwater source and target for storage of surface water using ASR for municipal water suppliers like Tigard, Tualatin, Tualatin Valley Water District, Beaverton, and Salem further to the south. However, there are several processes that can modify the specific, and overall, hydraulic behavior of CRBG aquifers and aquitards. These include tectonic fracturing forming faults and joints, folding, secondary mineralization, and construction of uncased water wells through multiple CRBG aquifers. Another critical aspect with regards to interflow zones, that is not commonly recognized, is their potential lateral variability. For example, thick flow top breccias are known to abruptly end with a much thinner normal flow top taking its place. These intraflow structures and variations can result in radically changing the hydraulic properties and behavior of individual CRBG aquifers. Currently, it is not possible to predict the distribution and extent of CRBG flow top and flow bottom features.

Numerous faults are present within the CWD service area (see Figure 2). Faults have been found to affect the CRBG aquifer system in a number of ways including:

- Forming barriers to the lateral and vertical movement of groundwater; a series of faults can create hydrologically isolated areas.
- Providing a vertical pathway (of varying length) for groundwater movement allowing otherwise isolated CRBG aquifers to be in direct hydraulic communication.
- Exposing interflow zones and creating local opportunities for aquifer recharge and/or discharge.

- The effect of faults within the project area are unknown, but are suspected, to act as barriers to groundwater flow in the CRBG aquifer system based on the interpreted offset in mapped geologic faults (Evarts et al., 2013; Beeson, Tolan and Anderson,1989; Phillips, 1987).
- Compartmentalizing individual aquifers (i.e., creating a groundwater reservoir of limited lateral extent that is bounded on all sides and limiting water production capacity).

Lastly, a number of different secondary processes that occur after emplacement of the basalt flow can change the physical characteristics of CRBG interflow zones. Secondary processes fundamentally change the original physical (and hydraulic) characteristics of CRBG flow tops and flow bottoms (i.e. the interflow zones), typically lowering their permeability.

The two most important of these processes are paleosol development and secondary mineralization and precipitation. Paleosol development occurs between emplacement of CRBG flows, through the weathering and chemical breakdown of the glassy vesicular flow top which leads to soil formation. This process typically alters and destroys the original physical texture of a portion of the flow top as well as most of its original permeability. Within the CWD service area, paleosol development would be anticipated to occur on the uppermost Sentinel Bluffs member flow of the Grande Ronde Basalt (i.e. Vantage Horizon). The Vantage Horizon is relatively thin in the Portland Basin.

After the emplacement and burial of the CRBG flows, secondary minerals (e.g., silica, cryptocrystalline quartz, calcite, zeolite, pyrite, clay minerals, etc.) can form or precipitate to partially or completely fill existing voids within interflow zones. This process also is important in sealing the cooling fractures in the dense flow interiors. The net effect of secondary mineralization on CRBG interflow zones is a reduction, ranging from slight to total, in the permeability of these zones that limits groundwater flow.

Basin Fill Deposits - Troutdale Formation

From late Miocene through the Pliocene the Portland Basin subsided and was filled with fluvial and lacustrine sediments transported into the basin by the Columbia River and streams flowing off the Cascade Range (Evarts, Et al, 2013). In the CWD service area, the basin-fill sediments are mapped as the hyaloclastic sandstone member of the Troutdale Formation and are present at the surface, except where covered by a thick deposit of Quaternary loess and volcanic rocks of the High Cascades. Beds and lenses of conglomerate occur within the hyaloclastic sandstone. The hyaloclastic sandstone member may be as thick as 600 feet. Most of the wells in the CWD service area are completed in the hyaloclastic sandstone member (Troutdale aquifer) and are low yielding wells capable of supporting exempt uses (i.e., domestic water supply). The hyaloclastic sandstone member is considered a confining unit in other parts of the Portland Basin and is correlative to the Willamette confining unit of Gannett and Caldwell (1998).

High Cascade Range Volcanics and Boring Lavas

Pliocene to Pleistocene age basalt and basaltic andesite flows overly the hyaloclastite sandstone member in the eastern third of the CWD service area, generally east of Crown Point. Chamberlain Hill in the northwest corner of the CWD service area is a vent from which basalt lava flows and cinders erupted during the Pleistocene (Evarts, Et al, 2013). Basalt from Chamberlain Hill has been dated at 1.16 million years. This vent is grouped with the many other vents of the Boring Volcanic Field in the Portland Basin and northwestern Oregon.

Several basalt flows have been described as interbedded with the Troutdale Formation (Tolan and Beeson, 1984; Evarts, Et al, 2013). High Cascades volcanics cap the ridge south of Howard Canyon and have an apparent thickness of approximately 400 feet. Wells up to 215 feet deep northeast of the east end of the study area and south of Pepper Mountain do not fully penetrate the High Cascade flows. Yields in wells completed in the High Cascade volcanics and Boring Lavas are relatively lower than those completed in CRBG, suggesting limited potential as a municipal supply source.

Regulatory Well Siting and Construction Limitations

The OWRD has specific rules for the Sandy River Basin under OAR 690-503 that limit the development of groundwater and surface waters for municipal, domestic, industrial and agricultural uses. The OWRD developed the Sandy River Basin program to manage and protect instream flows in the Sandy River Basin, which was identified as being over appropriated. Additionally, all groundwater within the shallow Troutdale aquifer or any well within a ¼-mile of a drainage or tributary of the Sandy River is considered to be in direct hydraulic connection with surface water and therefore would interfere or capture groundwater that would otherwise discharge to surface water.

The specific objectives of the Sandy Basin Program are as follows:

1. Uphold existing legislative withdrawals and grants, and state scenic waterway designations, consistent with statutory direction.

2. Protect existing rights.

3. Maintain and enhance instream and scenic values in the Sandy River Scenic Waterway and Columbia Gorge and throughout the Sandy Basin by limiting new out-of-stream appropriations from natural summer flows, and protecting remaining instream flows in the Sandy River main stem and its tributaries.

4. Minimize groundwater/surface water hydraulic interference.

5. Condition permits to regulate future use of groundwater in areas of documented declines near the city of Sandy.

Permits to use groundwater may be issued only for the following classified uses:

1. Except as provided in sections (2) and (3) of this rule, the groundwater resources of the Sandy Basin are classified for commercial, group domestic, industrial, irrigation, mining, municipal, and statutorily exempt groundwater uses.

2. Groundwater from the shallow Troutdale aquifer is classified for exempt uses only (within the Sandy-Boring Groundwater Management Area), such as . . . .?.

3. Groundwater hydraulically connected to, and within ¼- mile of, surface water shall be classified for the same uses as the surface water source and for uses exempted by ORS 537.545.

The statutory requirements of the Sandy Basin Program limit the ability to develop groundwater within the CWD service area; however, many of the requirements can be addressed by selection of the water supply well location and the proper design and construction of the water supply well. The well would need to be constructed in an aquifer other than the shallow Troutdale aquifer and that isn't hydraulically connected to surface water (i.e. a deeper, confined aquifer). The new groundwater permit authorizing the use of groundwater also would be conditioned to limit groundwater declines observed in aquifers in the Sandy-Boring Groundwater Management Area.

Given these limitations, the CRBG is the hydrogeologic unit that a new water supply well would target. Recharge and hydraulic connection to surface water bodies of the CRBG appear to be limited by the low permeability of the clay and claystone that is generally present immediately overlying the CRBG hydrogeologic unit(s) and the dense flow interiors between the individual interflow zones within CRBG. The target interflows for the water supply within the CRBG system would be within the Grande Ronde of the CRBG, below the Vantage Horizon interbed. The deeper Grande Ronde basalt is typically highly productive in the Portland Basin and is a regionally productive unit for municipal water supply wells as well as ASR wells.

Demonstrated capacity at wells within the CWD service area (MULT 74054) and other nearby wells (CLAC 963) indicate that the CRBG is capable of the high yields needed to provide redundancy to the CWD water supply system. Additionally, the OWRD has recently approved a groundwater authorization for a CRBG well located within the service area and adjacent to the Sandy River. The conceptual design of a new water supply well completed within the CRBG is presented in the next section.

CRBG Well Design

The design of the new water supply well includes the following key components that affect both initial capital construction costs, operation and maintenance, and life cycle costs of the well:

- Well Depth
- Target production rate (i.e. pump size)
- Annular seal depth
- Production casing depth
- Production casing materials
- Liner materials (if needed)
- Pumping water level
- CRBG borehole wall stability.

Available geologic and hydrogeologic information indicates that the target CRBG aquifer will be encountered below 800 feet bgs. This would be the approximate target depth for the production casing and the annular seal depth. Based on the inferred thickness of the CRBG units in the vicinity of the CWD service area, the total well depth would be approximately 1,400 feet below ground surface (bgs). (See Appendix A). Previous interpretations of the CRBG presented by Conlon et. al. (2005) inferred a thickness in excess of 1,600 feet in the CWD service area. However, water quality in the deeper CRBG typically has naturally occurring high total dissolved solids and fluoride concentrations and other adverse water quality conditions that may not be acceptable for drinking water use without treatment (Steinkampf and Hearn, 1996; Stienkampf, 1989).

The anticipated static water level and pumping water level are anticipated to be above the bottom of the seal, assuming confined aquifer conditions.

Our conceptual well design assumes that stable borehole conditions will be encountered during drilling. Wells completed in the CRBG in the Portland Basin have historically been completed open borehole below the bottom of the casing; however, in some instances liners have been installed where the pump intake was installed below the bottom of the production casing and/or where unstable borehole conditions (i.e. caving/collapse) were observed. There are no data available to anticipate if borehole instability will be an issue in a CRBG well in the CWD service area.

The 2016 study suggested drilling a smaller diameter test well rather than drill a larger production well given the unknowns identified in the report and a target production capacity of 500 gpm. While cost savings are realized by drilling a smaller diameter well designed to meet the minimum requirements for the anticipated system demand of 500 gpm, the drilling and testing of a larger diameter well results in long term cost savings to develop the additional supply. Table 1 shows the estimated costs for a well capable of 1,000 gpm (16-inch diameter) and a well constructed to support 500 gpm (10-inch diameter). Driller's estimated costs are included as Attachment B.

Long-term cost savings for the higher initial capital costs of a large diameter well are realized if the the well is capable of the design capacity of the production well of 1,000 gpm. Specifically, if a smaller diameter well were drilled and a second well was necessary to meet CWD goals, the costs would be more than double the initial capital cost for the larger diameter well for additional permitting, infrastructure (i.e. new well house, distribution piping), testing, and changes to the distribution system operation and controls for a second well. On this basis, SCS recommends that the CWD consider drilling, construction and testing of the larger diameter well to allow additional redundancy and flexibility of the new water supply source in the future.

Planning level costs presented in Table 1 also includes engineering and consulting costs anticipated as part of the well installation, construction and testing program including:

- Technical specifications, bid documents and contracting support
- Construction Management/Field Oversight
- Reporting
- Permitting.

These four tasks are required to ensure that the well is constructed as designed to meet Oregon Health Authority (OHA) and OWRD well requirements and that the new groundwater source will be approved and permitted as a new municipal water supply. A detailed description of the permitting requirements is provided in the next section.

3 REGULATORY FRAMEWORK AND PATHWAY

This section describes (1) the regulatory pathway and "next steps" to apply for a new groundwater right for developing the new water supply well, and (2) the plan submittal and review for a new drinking water source required by OHA.

The regulatory pathway to developing the new source includes the following:

- Multnomah County Land Use Compatibility (LUCs) Review

- OHA plan review
- Water rights permitting.

The LUCs is required as part of the OHA plan review and water rights permitting process. The LUCs is a form used by a state agency and local government to determine whether a land use proposal is consistent with local government's comprehensive plan and land use regulations. A more detailed description of the requirements for the OHA plan review and water right process is provided below.

OHA Plan Review

The OHA requires the following be submitted and approved prior to adding a water supply well to an existing system:

- Plans prepared by an Oregon Professional Engineer or an Oregon Registered Geologist be submitted prior to construction of the well
- A LUCs with approval from the local planning authority (i.e., Multnomah County), which is also required for the water right application.
- A copy of the water right permit authorizing the proposed use from OWRD
- The appropriate plan review fee.

If the new water supply well is an "exploratory well" then the required plan review can be performed after the well is tested and a water right is obtained; however, it is recommended to provide the proposed well construction for OHA review and consult with OHA to ensure (1) that it meets minimum standards, (2) the location and site plan meets all set back requirements, and (3)ownership and control are demonstrated prior to drilling, installation and construction of the well. Given the location and proposed construction SCS does not anticipate any issues with the proposed project.

Once the well is drilled, constructed and tested, the following is required to be submitted as part of the plan review process:

- Well drillers' report – documenting the well construction. Results of a long-duration pumping test (i.e. 72 hours) to determine aquifer hydraulic properties, proper sizing of the pumping system, and estimate anticipated operating conditions.
- Water quality testing to support a community water system.

The OHA plan review of the constructed well is to ensure that the well was constructed to meet surface seal requirements to be protective of groundwater quality, the well is capable of sustaining the proposed well yield and that water quality is suitable for drinking water purposes and meets all primary and secondary safe drinking water act maximum contaminant levels (MCLs) for regulated contaminants. The report documenting the well construction and testing outlined in Table 1 will support the OHA permitting requirements.

Water Right Permitting

As noted previously, a groundwater right authorizing municipal uses will be needed for the new water supply well. Most water rights are obtained in a three-step process. The CWD must apply to the OWRD for a permit authorizing the use of groundwater. The permit application will be reviewed to determine if groundwater is available and the requested use is allowed within OWRD rules. This review will include the potential for injury to existing water users, water availability, and the potential for hydraulic connection with surface water. If no concerns or limitations are identified, the OWRD will provide a proposed final order, with approval of the final order after a public comment period.

While the 2016 study and subsequent re-evaluation of the hydrogeology and conversations with OWRD staff about groundwater availability in the CWD service area suggests that the CRBG is a viable source, SCS recommends a pre-application meeting with OWRD staff to avoid any issues related to groundwater availability, hydraulic connection, or other regulatory concerns with the proposed project. Additional hydrogeologic information to support OWRD approval of the groundwater right could be identified and or presented as part of the initial consultation to support the permit application. Typically, taking this additional step prevents delays in approval of the permit if the OWRD requires additional information as part of the initial groundwater section review.

Initiating the permitting process before well construction decreases the time required to bring the well into operation. However, beginning the permitting process ahead of construction of the well may result in added costs should the well not meet CWD project objectives and goals. This is a minor risk relative to the construction costs for developing an alternative source for additional system capacity and/or storage. If CWD begins permitting after drilling, construction and testing of the well, this could result in delays to bring the well into operation. The maximum time for OWRD to approve a new groundwater permit is approximately 180 days under statute. This period may be longer if a contested case hearing is required prior to OWRD issuing the final order.

After the groundwater permit is issued the CWD must begin to construct a water system and begin putting water to the beneficial use within a certain time frame stipulated in the water right (i.e. the “C”-date). Typically this period is 5 years to demonstrate the water has been put to beneficial use. It is important to note that the permit will stipulate certain conditions that will also need to be met, such as annual water level monitoring, water use reporting, total and instantaneous pumping rates and volumes and other conditions. Once the claim of beneficial use is submitted and successfully demonstrates use and that conditions were met, a water right certificate will be issued by the OWRD and the water right will be “perfected”.

Lastly, should the CWD pursue operation of the well as an ASR well, an additional limited license would be required per OAR-690-350. This is a separate permitting process required by the OWRD for implementation of ASR testing. An ASR Limited License application requires additional information and supporting documentation outlining the proposed testing program including operational plans, quality assurance and quality control plans, water level monitoring, water quality monitoring and an annual report outline. Additionally, the 2016 hydrogeologic study and the well construction report will need to be expanded to evaluate additional considerations for ASR. Additional elements include aquifer response to ASR, potential resource problems, source water and groundwater geochemical compatibility, and recoverability of the stored water. Costs for developing the ASR system can be developed if the CWD pursue that option after drilling, testing and construction of the well.

REFERENCES CITED

Beeson, M.H., and Moran, M.R., 1979 Columbia River Basalt Group stratigraphy in western Oregon: Oregon Geology, v. 41, no. 1, p. 11-14.

Beeson, M.H. and Tolan, T.L., 1990, The Columbia River Basalt Group in the Cascade Range - a middle Miocene reference datum for structural analysis: American Geophysical Union Journal of Geophysical Research, v. 95, no. B12, p. 19,547-19,559.

Beeson, M.H. and Tolan, T.L., 1996, Field trip guide to Columbia River Basalt intracanyon flows in western Oregon and Washington - Ginkgo, Rosalia, and Pomona flows: Cordilleran Section Meeting of the Geological Society of America, Portland, Oregon, 35 p.

Beeson, M.H., Fecht, K.R., Reidel, S.P., and Tolan, T.L., 1985, Regional correlations within the Frenchman Springs Member of the Columbia River Basalt Group - new insights into middle Miocene tectonics of northwestern Oregon: Oregon Geology, v. 47, no. 8, p. 87-96.

Beeson, M.H., Tolan, T.L., and Anderson, J.L., 1989, The Columbia River Basalt Group in western Oregon - geologic structures and others factors that controlled emplacement patterns, in, Reidel. S.P., and Hooper, P.R., eds., Volcanism and Tectonism in the Columbia River Flood-Basalt Province: Geological Society of America Special Paper 239, p. 223-246.

Conlon, T.D, Wozniak, K.C., Woodcock, D., Herrera, N.B., Fisher, B.J., Morgan, D.S., Lee, K.K, and Hinkle, S.R., 2005. Ground-Water Hydrology of the Willamette Basin, Oregon. USGS Scientific Investigations Report 2005-5168. Prepared in cooperation with the Oregon Water Resources Department

Driscoll, F.G. (1986) Groundwater and Wells. 2nd Edition, Johnson Division, St Paul, 1089 p.

Evarts, R.C., O'Connor, J.E., and Tolan, T.L., 2013, Geologic map of the Washougal quadrangle, Clark County, Washington, and Multnomah County, Oregon: U.S. Geological Survey Scientific Investigations Map 3257, pamphlet 46 p.

Gannett, M.W., and Caldwell, R.R., 1998, Geologic framework of the Willamette lowland aquifer system, Oregon and Washington: U.S. Geological Survey Professional Paper 1424–A, 32 p.Reidel, S.P., Johnson, V.G., and Spane, F.A., 2002, Natural gas storage in basalt aquifers of the Columbia Basin, Pacific Northwest USA: a guide to site characterization, Pacific Northwest National Laboratory, Richland, Washington.

Phillips, W. M., compiler, 1987, Geologic map of the Vancouver quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-10, 27 p., 1 plate, scale 1:100,000.

Steinkampf, W.C., 1989, Water quality characteristics of the Columbia Plateau Regional Aquifer System in parts of Washington, Oregon, and Idaho: U.S. Geological Survey Open-File Report 95-467, 67 p.

Steinkampf, W.C., and Hearn, P.P., Jr., 1996, Ground-water geochemistry of the Columbia Plateau aquifer system, Washington, Oregon, and Idaho: U.S. Geological Survey Open-File Report 95-467, 67 p.

Table 1. Planning Level Costs for a New Water Supply Well

Contractor Task	16-inch Diameter Well (1000 gpm)	10-inch Diameter Well (500 gpm)
Mobilization	$40,000	$26,500
Drill/Install Temporary Conductor Casing	$5,800	$4,200
Drill Upper Borehole	$198,000	$142,500
Furnish/Install Production Casing (+2 to 800 ft bgs)	$85,000	$49,600
Grout Surface Seal (0 to 200 ft bgs)	$47,000	$38,400
Drill Open Hole (800 -1400 ft bgs)	$144,000	$87,000
Well Development	$5,000	$4,760
72 Hour Pumping Test	$56,500	$23,600
Perform Final Disinfection	$5,200	$4,000
Demobilization	$25,000	$12,000
Drilling Contractor Totals[1,2]	**$611,500**	**$392,560**
SCS Engineering Consulting Support		
Bid Package/Technical Specifications	$15,000	$15,000
Construction Oversight	$25,000	$20,000
Permitting Support	$15,000	$15,000
Reporting	$10,000	$10,000
Engineering/Consulting Support Totals	**$65,000**	**$60,000**
Project Totals	**$676,500**	**$452,650**
Cost of Additional Capacity ($/gal)[3]	**$675.5/gal**	**$905.3/gal**

<u>Notes:</u>

gpm = gallons per minute

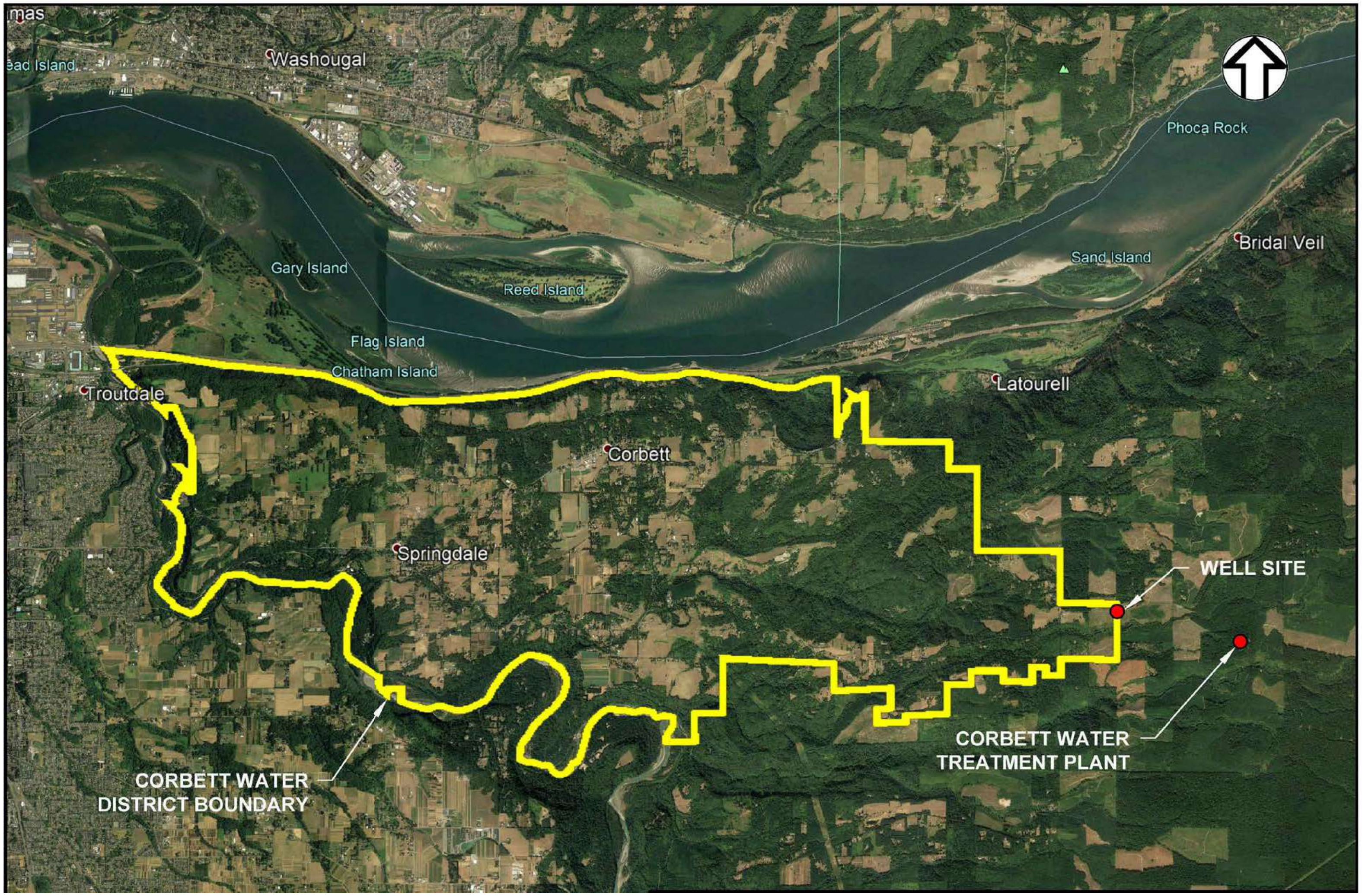
ft bgs = feet below ground surface

Estimated capacity and casing and pump size based on recommendations in Driscoll (1986)

[1] Drilling contractor costs assume standard construction well casing and liner materials of low-carbon steel. High Strength Low Alloy (HSLA) well casing and liner materials would extend the anticipated life of the well and cost ~ 25 percent more relative to low carbon steel. Steel and fuel prices subject to change.

[2] Drillers quotes in Appendix B were developed assuming a 1300 ft bgs deep well; SCS added an additional 100 ft to our estimate above.

[3] Cost per gallon assumes the wells can meet the design production rate of 1000 gpm or 500 gpm. Costs only account for initial capital cost outlay for drilling, construction, testing, and permitting of the well.

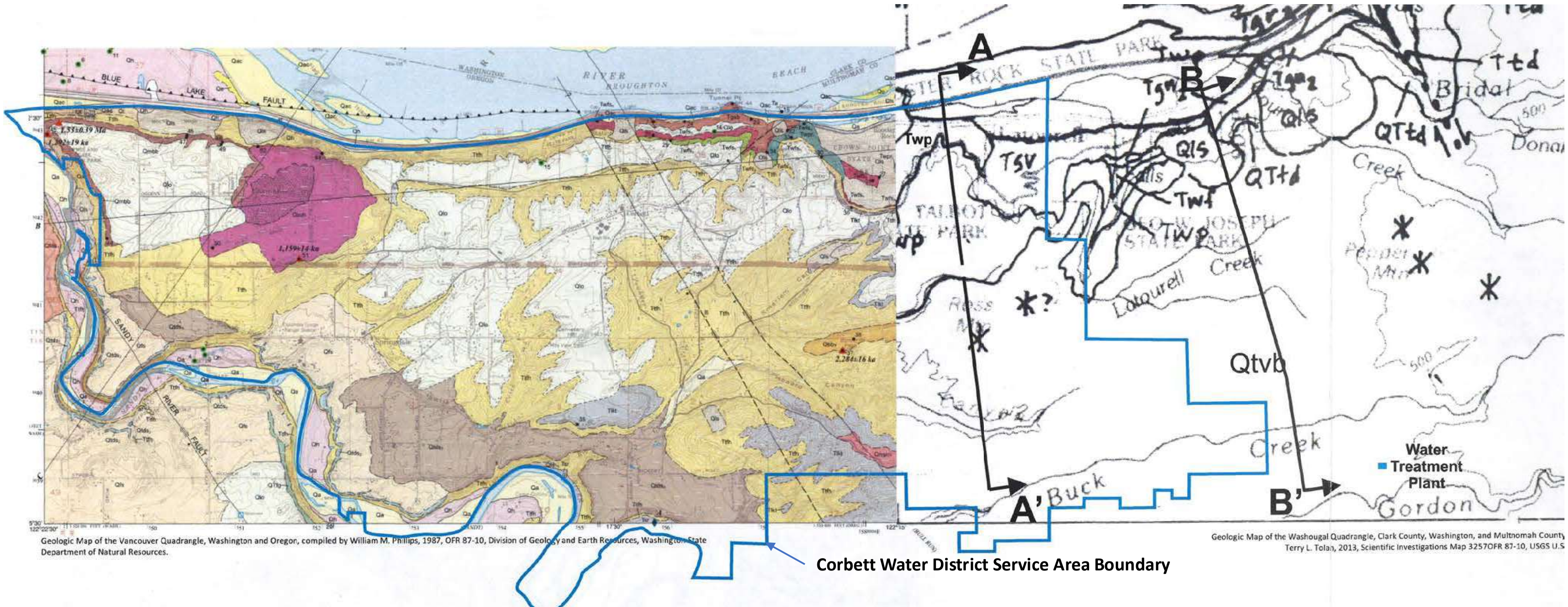


Corbett Service Area and New Water Supply Well Location

New Groundwater Supply Feasibility Study
Corbett Water District
Corbett, Oregon

SCS ENGINEERS

FEB-2019	BY: CDA/ - - -	FIGURE NO. 1
PROJECT NO. 04218051.00	REVISED BY: - - - / - - -	



Geologic Map of the Vancouver Quadrangle, Washington and Oregon, compiled by William M. Phillips, 1987, OFR 87-10, Division of Geology and Earth Resources, Washington State Department of Natural Resources.

Geologic Map of the Washougal Quadrangle, Clark County, Washington, and Multnomah County, Terry L. Tolan, 2013, Scientific Investigations Map 3257OFR 87-10, USGS U.S

Corbett Water District Service Area Boundary

Explanation

SURFICIAL DEPOSITS

Af	Artificial fill
Qe	Eolian deposits
Qac	Alluvium of Columbia River floodplain & channel
Qa	Alluvium
Qls	Landslide deposits
Qh	Deposits derived from the Mount Hood volcano
Qlo	Loess
Qtds$_2$	Terrace deposits 2
Qtds$_3$	Terrace deposits 3
Qfs	Sand and silt facies

VOLCANIC ROCKS OF THE BORING VOLCANIC FIELD

Qmpm	Basaltic andesite of Pepper Mountain
Qbch	Basalt of Chamberlain Hill
Qmbb	Basalt of Broughton Bluff
Qbbv	Basalt of Bridal Veil Creek

BASIN-FILL DEPOSITS

QTfg	Unnamed fan gravel
Ttfh	Hyaloclastic sandstone member Troutdale Formation
Tlkt	Volcanic rocks of the High Cascade Range

Columbia River Basalt Group

- Wanapum Basalt
  - Priest Rapids Member
    - TVpr$_R$ Basalt of Rosalia
  - Frenchman Springs Member
    - Twfs$_s$ Basalt of Sentinal Gap
    - Twfs$_h$ Basalt of Sand Hollow
- Grande Ronde Basalt
  - Tgsb Sentinal Bluffs Member

VOLCANIC AND SEDIMENTARY ROCKS

Ta	Volcaniclastic sedimentary rocks (Skamania

Explanation

QUATERNARY SEDIMENTARY DEPOSITS

Qal	Alluvium
Qls	Landslide deposits

PLEISTOCENE-MIOCENE SEDIMENTARY DEPOSITS

QTtd	Troutdale Formation
QTvb	Volcanic Rocks Of the High Cascades
Tvs	Volcaniclastic sedimentary rocks (Skamania volcanics)

MIDDLE MIOCENE COLUMBIA RIVER BASALT GROUP FLOWS

Tsp	Pomona Member of the Saddle Mountains Basalt
Twp	Priest Rapids Member of the Wanapum Basalt
Twf	Frenchman Springs Member of the Wanapum Basalt
Ttd	no explanation given
Tgn$_2$	Grande Ronde Basalt normal polarity
Tgr$_2$	Grande Ronde Basalt reverse polarity

Contact—Solid where location is accurate; long-dashed where approximately located, short-dashed where inferred; dotted where concealed

Fault—Long-dashed where approximately located; short-dashed where inferred; dotted where concealed; queried where existence or extent uncertain. Ball and bar on downthrown side. Arrows show relative horizontal movement

Reverse fault—Dashed where inferred, dotted where concealed. Sawteeth on upper plate

25 **Strike and dip of beds**

5 **Strike and dip of platy parting in lava flows**

25 **Strike and dip of eutaxitic structure in pumiceous tuff**

Notes:

Figure modified from Mark Yinger and Associates, 2016

Base Map Sources

Phillips, W. M., compiler, 1987, Geologic map of the Vancouver quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-10, 27 p., 1 plate, scale 1:100,000.

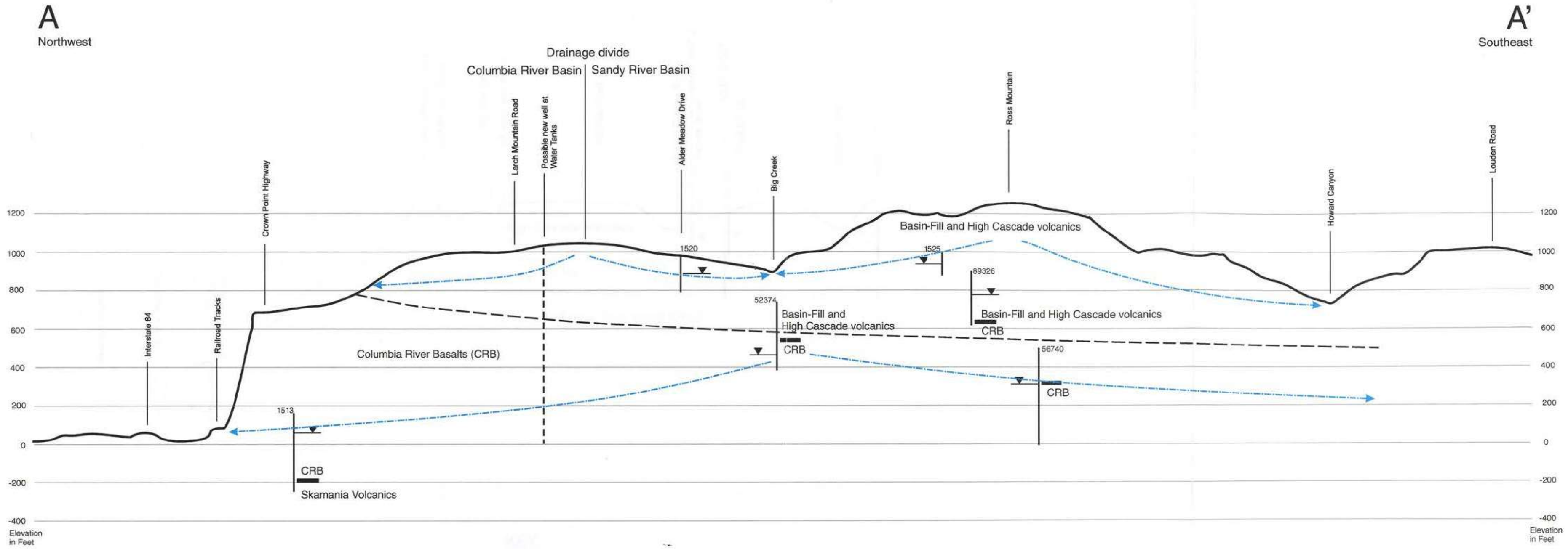
Evarts, R.C., O'Connor, J.E., and Tolan, T.L., 2013, Geologic map of the Washougal quadrangle, Clark County, Washington, and Multnomah County, Oregon: U.S. Geological Survey Scientific Investigations Map 3257, pamphlet 46 p.

Corbett Service Area and Vicinity Geologic Map

New Groundwater Supply Feasibility Study
Corbett Water District
Corbett, Oregon

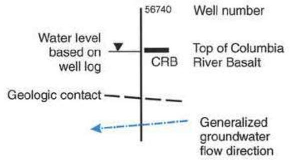
SCS ENGINEERS

FEB-2019	BY: CDA/ 2-7-2019	FIGURE NO.
PROJECT NO. 04218051.00	REVISED BY: ---/---	2



Well Log Number	Offset from Cross Section (approx.)
1513	5470' East
1525	910' East
1520	7240' East
52374	5830 ' West
56740	8460 West
89326	6390' East

KEY



0 1000 2000

Horizontal Scale in Feet
Vertical Exaggeration = 2X

The trace of the cross section is shown on Figure 2

Notes:

Figure from Mark Yinger and Associates, 2016. Geologic and Hydrogeolgoic were interpretations presented in 2016 study.

Base Map Sources

Phillips, W. M., compiler, 1987, Geologic map of the Vancouver quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-10, 27 p., 1 plate, scale 1:100,000.

Evarts, R.C., O'Connor, J.E., and Tolan, T.L., 2013, Geologic map of the Washougal quadrangle, Clark County, Washington, and Multnomah County, Oregon: U.S. Geological Survey Scientific Investigations Map 3257, pamphlet 46 p.

Cross Section A- A'
Corbett Service Area
New Groundwater Supply Feasibility Study
Corbett Water District
Corbett, Oregon

SCS ENGINEERS

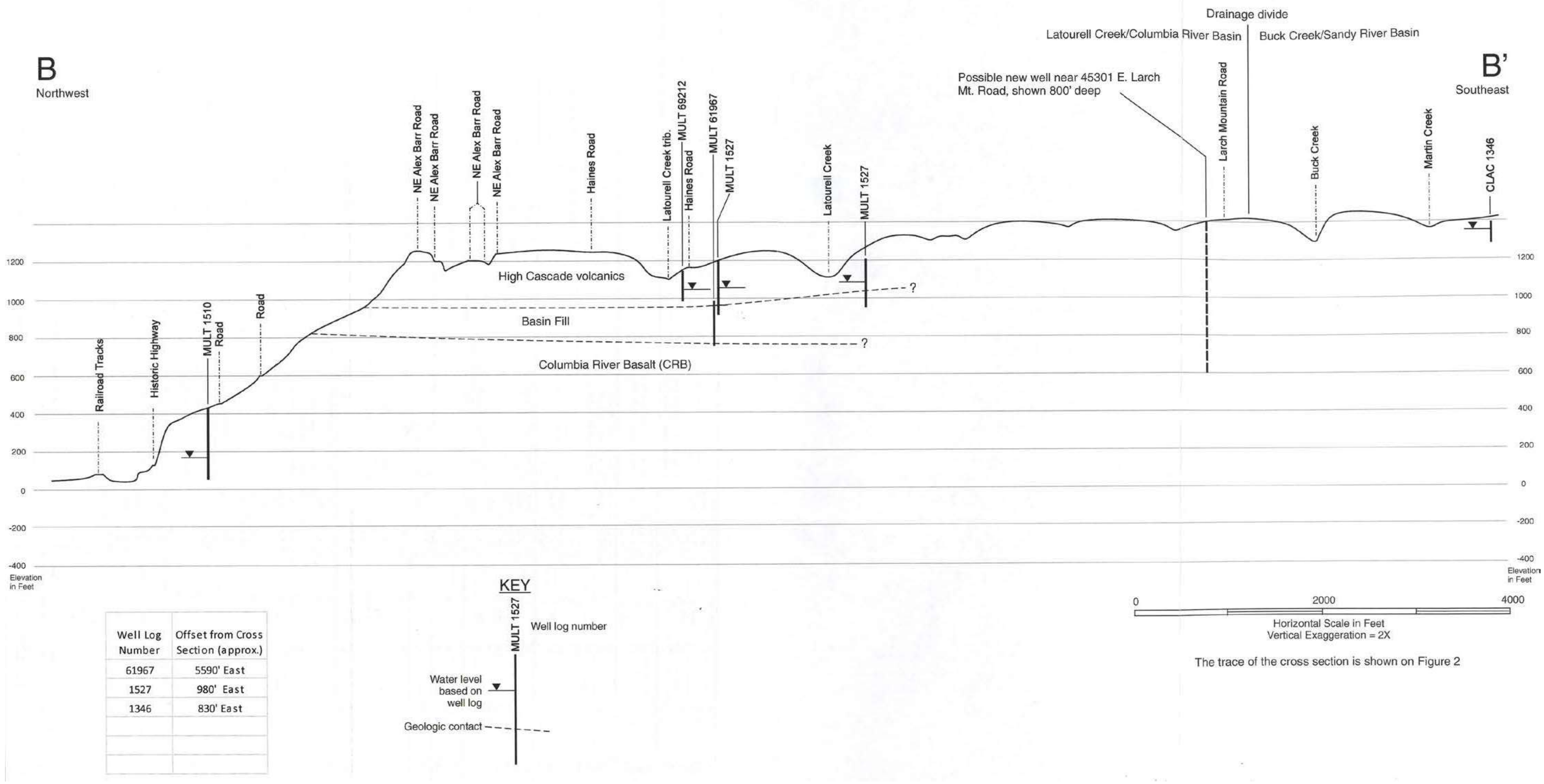
FEB-2019

PROJECT NO.
04218051.00

BY:
CDA/2-7-2019

REVISED BY:
---/---

FIGURE NO.
3



The trace of the cross section is shown on Figure 2

Well Log Number	Offset from Cross Section (approx.)
61967	5590' East
1527	980' East
1346	830' East

Notes:

Figure from Mark Yinger and Associates, 2016. Geologic and Hydrogeolgoic were interpretations presented in 2016 study.

Base Map Sources

Phillips, W. M., compiler, 1987, Geologic map of the Vancouver quadrangle, Washington: Washington Division of Geology and Earth Resources Open File Report 87-10, 27 p., 1 plate, scale 1:100,000.

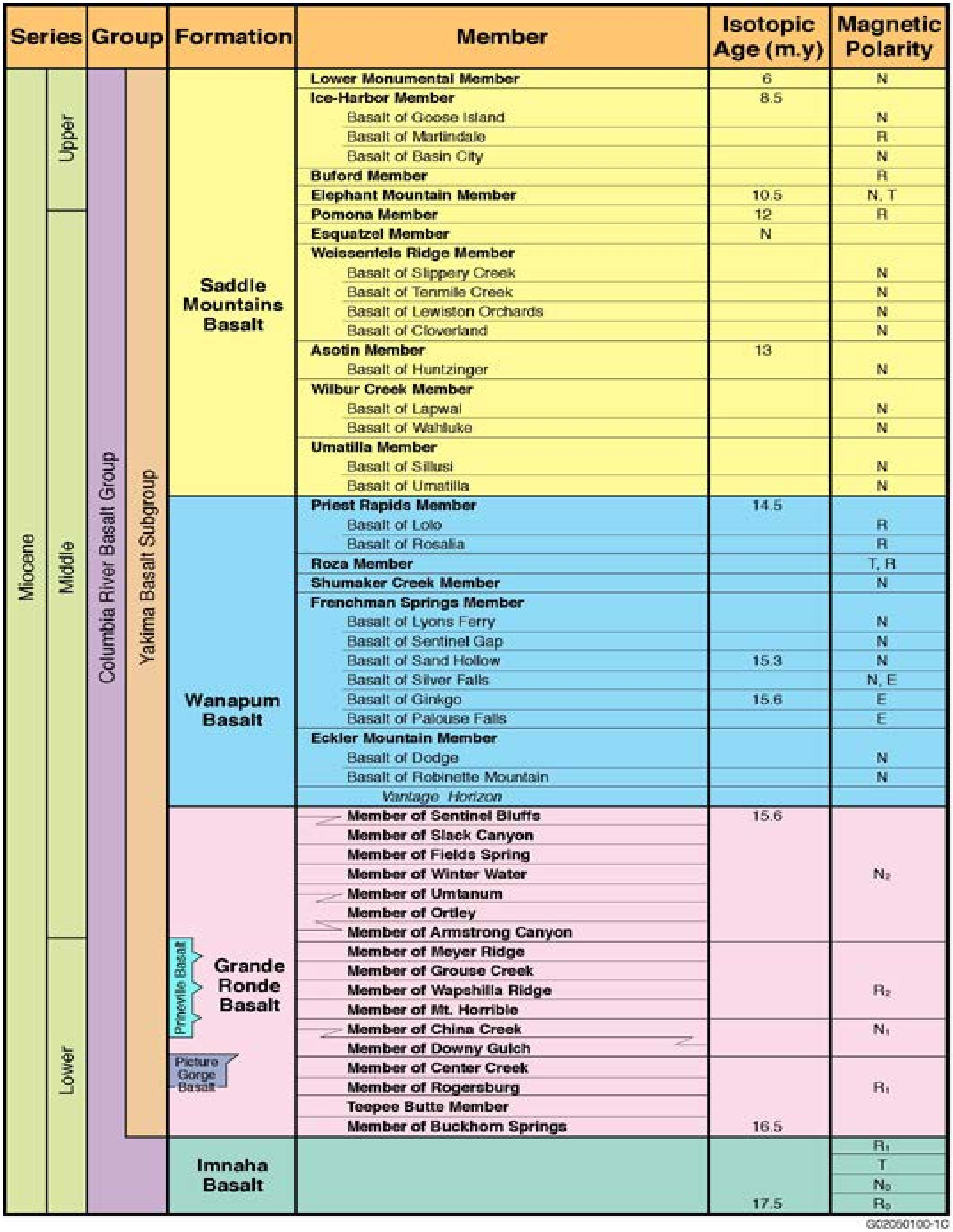
Evarts, R.C., O'Connor, J.E., and Tolan, T.L., 2013, Geologic map of the Washougal quadrangle, Clark County, Washington, and Multnomah County, Oregon: U.S. Geological Survey Scientific Investigations Map 3257, pamphlet 46 p.

Cross Section B- B'
Corbett Service Area

New Groundwater Supply Feasibility Study
Corbett Water District

SCS ENGINEERS

FEB-2017	BY: CDA/ 2-7-2019	FIGURE NO. 4
PROJECT NO. 04218051.00	REVISED BY: ---/---	



Series		Group		Formation	Member	Isotopic Age (m.y)	Magnetic Polarity
Miocene	Upper	Columbia River Basalt Group	Yakima Basalt Subgroup	Saddle Mountains Basalt	**Lower Monumental Member**	6	N
					Ice-Harbor Member	8.5	
					Basalt of Goose Island		N
					Basalt of Martindale		R
					Basalt of Basin City		N
					Buford Member		R
					Elephant Mountain Member	10.5	N, T
	Middle				**Pomona Member**	12	R
					Esquatzel Member	N	
					Weissenfels Ridge Member		
					Basalt of Slippery Creek		N
					Basalt of Tenmile Creek		N
					Basalt of Lewiston Orchards		N
					Basalt of Cloverland		N
					Asotin Member	13	
					Basalt of Huntzinger		N
					Wilbur Creek Member		
					Basalt of Lapwai		N
					Basalt of Wahluke		N
					Umatilla Member		
					Basalt of Sillusi		N
					Basalt of Umatilla		N
				Wanapum Basalt	**Priest Rapids Member**	14.5	
					Basalt of Lolo		R
					Basalt of Rosalia		R
					Roza Member		T, R
					Shumaker Creek Member		N
					Frenchman Springs Member		
					Basalt of Lyons Ferry		N
					Basalt of Sentinel Gap		N
					Basalt of Sand Hollow	15.3	N
					Basalt of Silver Falls		N, E
					Basalt of Ginkgo	15.6	E
					Basalt of Palouse Falls		E
					Eckler Mountain Member		
					Basalt of Dodge		N
					Basalt of Robinette Mountain		N
					Vantage Horizon		
				Grande Ronde Basalt	**Member of Sentinel Bluffs**	15.6	N_2
					Member of Slack Canyon		
					Member of Fields Spring		
					Member of Winter Water		
					Member of Umtanum		
					Member of Ortley		
					Member of Armstrong Canyon		
	Lower			Prineville Basalt	**Member of Meyer Ridge**		R_2
					Member of Grouse Creek		
					Member of Wapshilla Ridge		
					Member of Mt. Horrible		
					Member of China Creek		N_1
					Member of Downy Gulch		
				Picture Gorge Basalt	**Member of Center Creek**		R_1
					Member of Rogersburg		
					Teepee Butte Member		
					Member of Buckhorn Springs	16.5	
				Imnaha Basalt			R_1
							T
							N_0
						17.5	R_0

G02060100-10

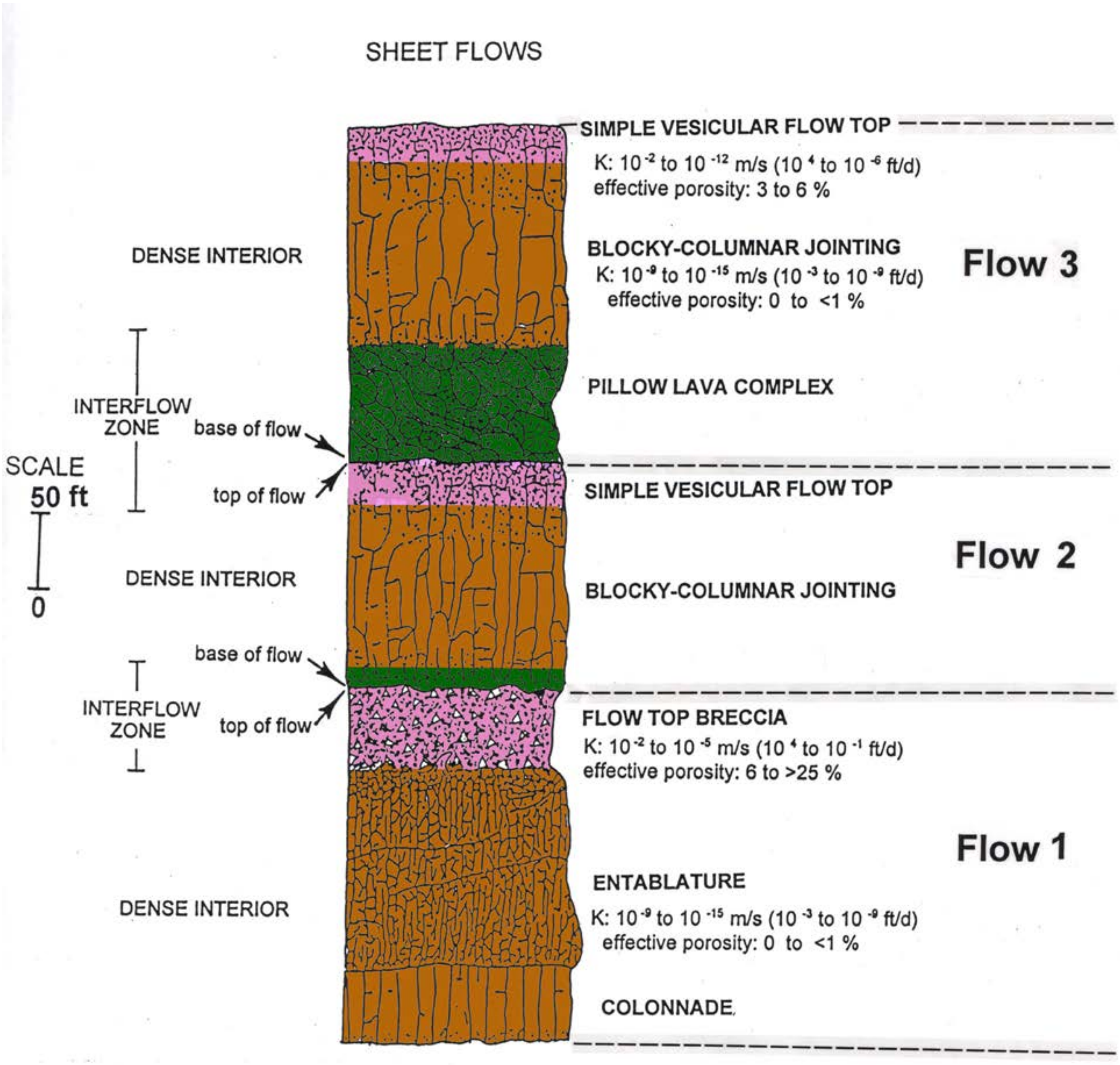
Notes:
Stratigraphy of the Columbia River Basalt Group. Modified from Tolan and others (1989) and Reidel and others (1989b).

Columbia River Basalt Stratigraphy

New Groundwater Supply Feasibility Study
Corbett Water District

FEB-2019	BY: CDA/ 2-7-2019	FIGURE NO. **5**
PROJECT NO. 04218051.00	REVISED BY: - - - / - - -	

SCS ENGINEERS



<u>Notes:</u>

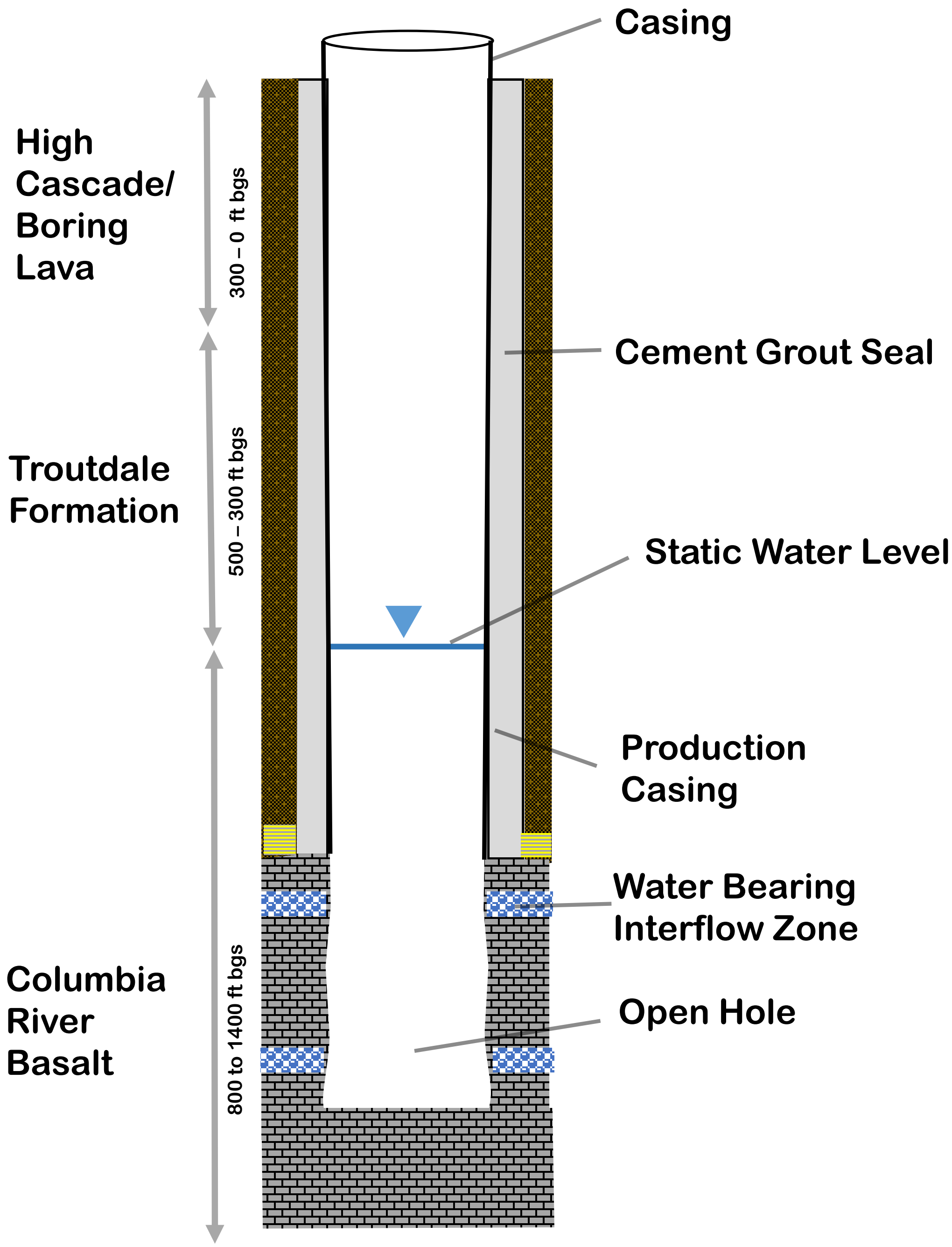
Diagrammatic representation of common CRBG intraflow structure and terminology. Flow tops are highlighted in pink, dense interiors in orange, and flow bottoms in green. From Tolan and others (2000).

CRBG Interflow Structure and Terminology

New Groundwater Supply Feasibility Study
Corbett Water District

FEB-2019	BY: CDA/ 2-7-2019	FIGURE NO.
PROJECT NO. 04218051.00	REVISED BY: - - - / - - -	6

SCS ENGINEERS



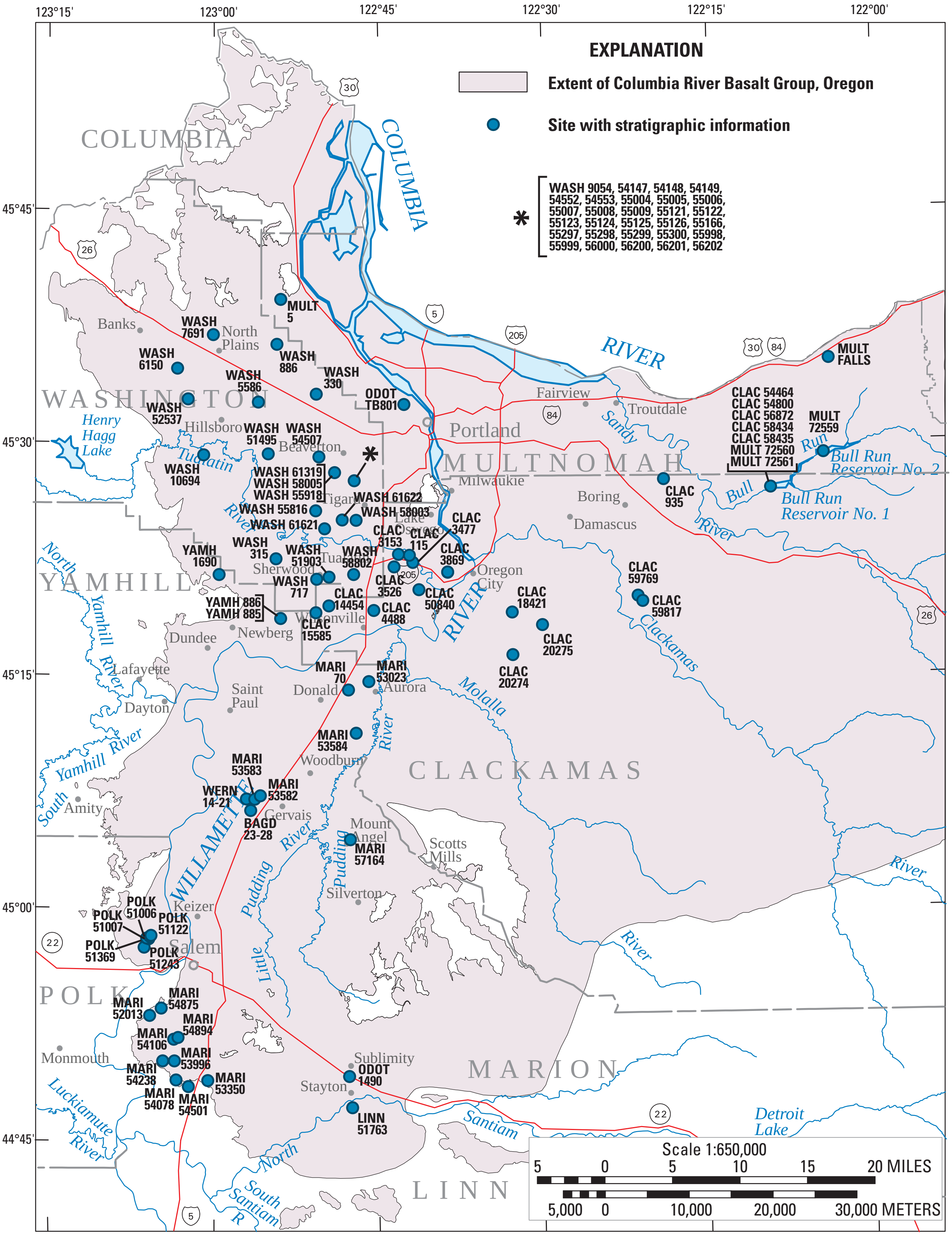
Conceptual Design for Basalt Well

New Groundwater Source Feasibility
Corbett Water District
Corbett, Oregon

FEB-2019	BY: CDA/ 2-7-2019	FIGURE NO. 7
PROJECT NO. 04218051.00	REVISED BY: - - - / - - -	

SCS ENGINEERS

APPENDIX A COLUMBIA RIVER BASALT WELL LOGS

123°15'
123°00'
122°45'
122°30'
122°15'
122°00'
45°45'
45°30'
45°15'
45°00'
44°45'
EXPLANATION
Extent of Columbia River Basalt Group, Oregon
Site with stratigraphic information
*
WASH 9054, 54147, 54148, 54149, 54552, 54553, 55004, 55005, 55006, 55007, 55008, 55009, 55121, 55122, 55123, 55124, 55125, 55126, 55166, 55297, 55298, 55299, 55300, 55998, 55999, 56000, 56200, 56201, 56202
COLUMBIA
COLUMBIA
RIVER
WASHINGTON
MULTNOMAH
YAMHILL
CLACKAMAS
POLK
MARION
LINN
30
26
5
205
30
84
84
205
26
22
22
5
Banks
North Plains
Hillsboro
Beaverton
Portland
Fairview
Troutdale
Milwaukie
Tigard
Lake Oswego
Tualatin
Sherwood
Wilsonville
Newberg
Dundee
Lafayette
Dayton
Saint Paul
Donald
Aurora
Oregon City
Boring
Damascus
Woodburn
Gervais
Amity
Mount Angel
Scotts Mills
Silverton
Keizer
Salem
Monmouth
Sublimity
Stayton
Henry Hagg Lake
Tualatin River
North Yamhill River
Yamhill River
South Yamhill River
Sandy
Bull Run
Bull Run Reservoir No. 2
Bull Run Reservoir No. 1
Clackamas River
Molalla River
RIVER
WILLAMETTE
Pudding River
Pudding
Little
River
Luckiamute River
Santiam
North
South Santiam R
Detroit Lake
MULT 5
WASH 7691
WASH 6150
WASH 886
WASH 5586
WASH 330
ODOT TB801
WASH 52537
WASH 51495
WASH 54507
WASH 10694
WASH 61319
WASH 58005
WASH 55918
WASH 55816
WASH 61622
WASH 58003
WASH 61621
WASH 315
WASH 51903
WASH 58802
WASH 717
YAMH 1690
YAMH 886
YAMH 885
CLAC 3477
CLAC 3153
CLAC 115
CLAC 3869
CLAC 3526
CLAC 50840
CLAC 14454
CLAC 4488
CLAC 15585
CLAC 18421
CLAC 20275
CLAC 20274
CLAC 59769
CLAC 59817
CLAC 935
CLAC 54464
CLAC 54800
CLAC 56872
CLAC 58434
CLAC 58435
MULT 72560
MULT 72561
MULT 72559
MULT FALLS
MARI 70
MARI 53023
MARI 53584
MARI 53583
MARI 53582
WERN 14-21
BAGD 23-28
MARI 57164
POLK 51006
POLK 51007
POLK 51122
POLK 51369
POLK 51243
MARI 52013
MARI 54875
MARI 54894
MARI 54106
MARI 53996
MARI 54238
MARI 54078
MARI 54501
MARI 53350
ODOT 1490
LINN 51763
Scale 1:650,000
5 0 5 10 15 20 MILES
5,000 0 10,000 20,000 30,000 METERS

STATE OF OREGON

WATER WELL REPORT

(as required by ORS 537.765)

RECEIVED
OCT 30 1985
WATER RESOURCES DEPT
SALEM, OREGON

CLAC 00335

PLEASE TYPE or PRINT IN INK

1S/4E-27cb
(for official use only)

(1) OWNER:

Name J. Frank Schmidt & Son Co.
Address 9500 SE 327th
City Boring State Oregon
90009

(2) TYPE OF WORK (check):

New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

(3) TYPE OF WELL:

Rev
Rotary Air ☒ Driven ☐
Rotary Mud ☒ Dug ☐
Cable ☒ Bored ☐

(4) PROPOSED USE (check):

Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☒ Thermal: Withdrawal ☐ Reinjection ☐
Other: Piezometric ☐ Grounding ☐ Test ☐

(5) CASING INSTALLED:

Steel ☒ Plastic ☐
Threaded ☐ Welded ☒
16 " Diam. from +1.5 ft. to 709 ft. Gauge .375
12 " Diam. from 695 ft. to 1116 ft. Gauge .330

LINER INSTALLED:

Steel ☐ Plastic ☐
Threaded ☐ Welded ☐
" Diam. from ft. to ft. Gauge

(6) PERFORATIONS:

Perforated? ☐ Yes ☒ No
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

(7) SCREENS:

Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot Size Set from ft. to ft.
Diam. Slot Size Set from ft. to ft.

(8) WELL TESTS:

Drawdown is amount water level is lowered below static level

Was a pump test made? ☒ Yes ☐ No If yes, by whom? Layne
Yield: 1180 gal./min. with 158 ft. drawdown after 2½ hrs.
1062 " 127 " 3 "
~~Air test~~ 885 gal./min. ~~with drill stem at~~ 89' ~~ft.~~" 3⅓ hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water 74°F Depth artesian flow encountered ft.

(9) CONSTRUCTION:

Special standards: Yes ☐ No ☒
Well seal—*Material* used
Well sealed from land surface to See attached sketch ft.
Diameter of well bore to bottom of seal in.
Diameter of well bore below seal in.
Amount of sealing material Cement 254 sacks ☒ pounds ☐
How was cement grout placed? Pumped - Methods A & C

Was pump installed? no Type HP Depth ft.
Was a drive shoe used? ☒ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of Water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

(10) LOCATION OF WELL by legal description:

County Clackamas NW ¼ SW ¼ of Section 27 of
Township 1S (Township is North or South), Range 4E (Range is East or West), WM.
Tax Lot Lot Block Subdivision
MAILING ADDRESS OF WELL (or nearest address) See OWNER
Designated Hood Acres Well No. 5

(11) WATER LEVEL of COMPLETED WELL:

Depth at which water was first found approximately 180 ft.
Static level 528 ft. below land surface. Date 8/7/85
Artesian pressure lbs. per square inch. Date

(12) WELL LOG:

Diameter of well below casing 12
Depth drilled 1783 ft. Depth of completed well 1783 ft.

Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

MATERIAL	From	To	SWL
See Attached			

Date work started 11/16/84 /completed 10/1/85
Date well drilling machine moved off of well 10/1 1985

(unbonded) Water Well Constructor Certification (if applicable):

This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.

[Signed] Date , 19

(bonded) Water Well Constructor Certification:

Bond EX490-652 (number) Issued by: American States Ins. (Surety Company Name)
On behalf of Schneider Equipment, Inc. (type or print name of Water Well Constructor)

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

(Signed) Stephen J Schneider (Water Well Constructor)
(Dated) 10/28/85

NOTICE TO WATER WELL CONSTRUCTOR
The original and first copy of this report are to be filed with the WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310 within 30 days from the date of well completion.

SP*46866-690

SEI #8512

RECEIVED
OCT 30 1985
WATER RESOURCES DEPT
SALEM, OREGON

WELL LOG
J. FRANK SCHMIDT & SON CO.
HOOD ACRES WELL NO. 5

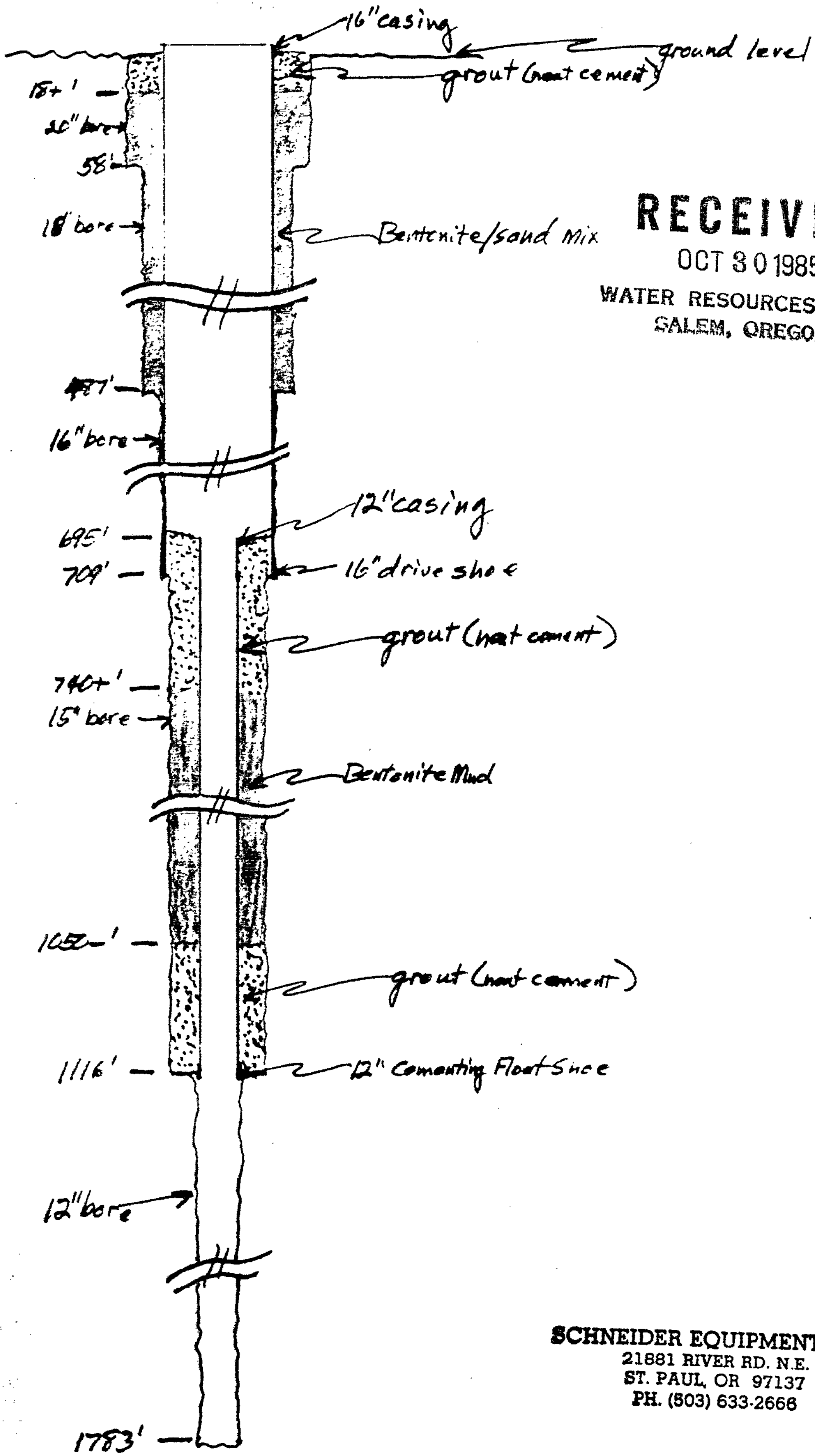
Depth in Feet	
0 - 2	Top soil, brown
2 - 31	Clay, red
31 - 48	Clay, multi-colored tan-yellow, gritty
48 - 52	Boulders & gravel, some clay
52 - 68	Gravel & cobbles
68 - 69	Gravel & cobbles with clay, brown
69 - 71	Sandstone, yellow
71 - 72	Clay, silty, grey
72 - 74	Gravel & cobbles
74 - 75	Sandstone (yellow brown)
75 - 84	Gravel & cobbles (boulders)
84 - 100	Gravel & boulders
100 - 121	Gravel & clay
121 - 124	Gravel & clay & boulders
124 - 136	Gravel & boulders with clay
136 - 148	Gravel, boulders & clay
148 - 152	Gravel & cobbles (loose)
152 - 155	Gravel & cobbles - 6"-8"
155 - 168	Gravel & cobbles cemented with clay
168 - 169	Boulder
169 - 176	Gravel & cobbles (cemented)
176 - 184	Gravel & cobbles cemented w/some clay
184 - 186	Gravel, 3" minus & sand coarse loose
186 - 197	Gravel & cobbles w/occas. boulder
197 - 210	Gravel & cobbles, some cemented
210 - 220	Gravel 6" minus w/some clay binder, yellow
220 - 224	Gravel w/some cobbles w/clay binder
224 - 228	Gravel & cobbles w/clay (some)
228 - 236	Gravel w/clay, tan
236 - 237	Clay tan w/gravel
237 - 251	Clay, tan & brown w/some gravel
251 - 255	Clay, light gray w/some gravel
255 - 263	Clay, tan & brown w/some gravel
263 - 267	Gravel & clay, brown
267 - 282	Clay, tan, gray & brown gritty & gravel
282 - 286	Clay, tan, gray & brown & gravel
286 - 299	Clay, tan w/occassional gravel layer
299 - 311	Clay, tan gritty
311 - 313	Clay, tan w/some gravel
313 - 316	Gravel w/clay layers
316 - 323	Gravel & clay, brown fine sandy, dry
323 - 332	Clay, brown
332 - 336	Clay, white & tan soft
336 - 344	Clay & broken gravel
344 - 346	Gravel w/some clay
346 - 348	Gravel w/trace of clay
348 - 365	Gravel & clay. brown silty
365 - 372	Clay, reddish brown w/broken gravel imbedded
372 - 375	Gravel & clay reddish brown
375 - 381	Clay & gravel brown

Depth in Feet			
381	–	386	Gravel w/clay & coarse sand imbedded brown
386	–	396	Gravel cemented, w/clay, brown
396	–	402	Gravel cemented w/coarse sandy clay brown
402	–	409	Gravel 8" minus w/some clay (looser)
409	–	424	Basalt, blk, fractured w/some yellow clay
424	–	433	Basalt, blk, med fractured w/some clay,yellow
433	–	440	Basalt, blk, fractured w/some clay, yellow
440	–	444	Gravel & clay tan
444	–	446	Clay tan firm sticky
446	–	451	Clay tan, sticky
451	–	457	Clay, med blue-gray
457	–	466	Clay, blue-gray soft
466	–	470	Clay, tan & brown firm sticky
470	–	473	Gravel & clay tan fine sandy
473	–	477	Clay, tan & brown w/broken rock imbedded
477	–	485	Clay, blue-gray, med
485	–	488	Sandstone blk w/some clay
488	–	491	Clay, drk blue-gray
491	–	493	Clay, gray
493	–	495	Sandstone, or cemented sand blk w/brown sandy clay
495	–	502	Clay, brown sandy, dry
502	–	503	Clay, reddish brown sticky
503	–	508	Clay, blue-gray sticky
508	–	517	Clay, blue w/sand blk imbedded, soft
517	–	524	Clay, blue-green, flakey med
524	–	526	Clay, blue-green drk w/sand imbedded, soft
526	–	527	Clay, blue-green & gray w/sand imbedded, med
527	–	529	Clay, gray firm
529	–	531	Clay, gray w/sand imbedded, med
531	–	533	Clay, blue & brown streaked fine sandy
533	–	541	Clay, brown fine sandy
541	–	546	Clay, tan brown, fine sandy w/firm streaks
546	–	550	Clay, gray, fine sandy
550	–	554	Clay, blue-green sticky, flakey
554	–	556	Clay, blue-green, med
556	–	560	Clay, gray, soft
560	–	564	Clay, blue & gray streaked, firm,sticky, flakey
564	–	570	Clay, blue-green, drk, fine sandy, med
570	–	576	Clay, gray silty, soft
576	–	592	Clay, blue, sticky
592	–	596	Clay, blue-gray, med sticky
596	–	599	Clay, blue & gray sandy, dry
599	–	601	Clay, gray, fine sandy, dry
601	–	603	Clay, gray, sticky
603	–	609	Clay, blue & gray, med soft
609	–	610	Clay, gray, fine, sandy
610	–	616	Clay, blue-gray, sticky
616	–	622	Clay, gray, fine sandy, dry
622	–	628	Clay, gray, fine sandy
628	–	632	Clay, gray, sticky
632	–	638	Clay, blue-green firm sticky
638	–	642	Claystone, gray, hard
642	–	656	Clay, gray & blue sticky w/hard streaks

Depth in Feet	
656 - 657	Clay, blue & gray sticky
657 - 662	Clay, blue-green sticky
662 - 673	Clay, gray, med sandy, firm, dry
673 - 675	Clay, blue-green & gray, med sandy,firm,dry
675 - 676	Clay, blue-gray sticky
676 - 677	Clay, blue-gray, fine sandy
677 - 697	Clay, gray, fine sandy
697 - 702	Clay, blue-green, flakey, firm
702 - 712	Clay, gray, fine sandy, firm
712 - 717	Clay, gray, fine sandy, soft
717 - 726	Clay, blue-gray, fine sandy, med
726 - 729	Clay, gray, fine sandy, firm
729 - 730	Clay, gray, sticky
730 - 732	Clay, gray, firm
732 - 735	Clay, blue, med
735 - 736	Clay, gray, fine sandy, firm
736 - 740	Clay, gray & blue, fine sandy, med
740 - 743	Clay, blue, sticky, med
743 - 745	Clay, blue w/firm streaks, sticky
745 - 749	Clay, blue, fine sandy, med
749 - 753	Clay, blue & gray, fine sandy, med
753 - 757	Clay, gray, med sandy, hard
767 - 770	Clay, gray, med, hard
770 - 777	Clay, gray, med sandy, firm
777 - 780	Clay, gray, med sandy, firm
780 - 786	Clay, gray, fine sandy, med
786 - 789	Clay, gray, fine sandy, med, w/wood
789 - 794	Clay, blue, sticky
794 - 798	Clay, gray, fine sandy w/hard layers
798 - 804	Clay, drk brown & gray streaked
804 - 805	Clay, drk brown, firm
805 - 830	Clay, blue & gray, little sandy med
830 - 860	Clay, gray, soft silty
860 - 872	Clay, gray, soft gritty
872 - 880	Clay, dark brown, fine sandy
880 - 890	Clay, blue green, soft
890 - 955	Clay layers of gray & blue green, soft
955 - 985	Clay, gray, med
985 - 1010	Clay, gray & blue green layers, med soft
1010 - 1035	Clay, dark gray, soft
1035 - 1042	Sandstone, gray, med
1042 - 1073	Clay, gray, soft
1073 - 1085	Clay, blue-green, soft
1085 - 1094	Clay, gray, soft
1094 - 1105	Siltstone & basalt, multi-color, soft
1105 - 1112	Siltstone & basalt, multi-color, med
1112 - 1147	Siltstone & basalt layers, multi-color, med
1147 - 1176	Basalt, black, med hard
1176 - 1202	Sandstone, multi-color, med with occasional clay layers
1202 - 1226	Basalt, black med w/sandstone & clay layers
1226 - 1307	Basalt, black, hard

Depth in Feet	
1307 - 1320	Basalt, black, soft, fractured, some clay, black
1320 - 1326	Basalt, black, hard
1326 - 1341	Basalt, black, med, fractured
1341 - 1369	Basalt, black, hard
1369 - 1392	Basalt, black, hard, some fractures
1392 - 1419	Basalt, black, soft-hard, fractured, some clay
1419 - 1424	Basalt, black, med, some fractures
1424 - 1435	Basalt, black, med
1435 - 1461	Basalt, black, med-hard
1461 - 1478	Basalt, black, soft, fractured
1478 - 1485	Basalt, black, med, some fractures
1485 - 1501	Basalt, black, med-hard S.W.L. 536'
1501 - 1506	Clay, dark grey, hard-crumbly, with basal & chips
1506 - 1509	Basalt, grey, hard
1509 - 1525	Basalt, black, med-hard
1525 - 1538	Basalt, black, med, vesicular & fractures
1538 - 1539	Basalt, black, soft-med, with claystone layers
1539 - 1542	Basalt & sandy clay layers, multi-colored, soft
1542 - 1550	Basalt, black, med-hard, some vesicles & fractures
1550 - 1553	Basalt, black & grey, vesicular, occ. fracture
1553 - 1557	Basalt, grey, med-hard
1557 - 1560	Shale, grey, occ. black basalt imbedded
1560 - 1569	Basalt, dark grey, soft-med, vesicular with some green shale
1569 - 1578	Basalt, black, med-hard, some vesicles & fractures
1578 - 1580	Basalt, black, hard
1580 - 1591	Basalt, black, med, some fractures
1591 - 1600	Basalt, black, hard
1600 - 1603	Basalt,black, hard with clay lenses
1603 - 1612	Basalt, black, hard
1612 - 1617	Clay, dark grey-black, gritty, med
1617 - 1627	Basalt, black, med, vesicular & fractures
1627 - 1657	Basalt, black, med-hard, some fractures/ vesicles, occ. grey basalt lenses
1657 - 1669	Basalt,grey, hard, some fractures/vesicles, some black
1669 - 1691	Basalt, grey, hard, occ. green shale lenses
1691 - 1707	Basalt, grey, hard
1707 - 1741	Basalt, grey, hard, occ. green shale lenses
1741 - 1750	Basalt, grey, hard
1750 - 1759	Basalt, dark grey, soft, broken fractured/ vesicular, W.B., S.W.L. 528'
1759 - 1765	Basalt, dark grey, soft-med, fractured/ vesicular
1765 - 1775	Basalt, grey, med, fractures
1775 - 1783	Basalt, grey, hard

J. Frank Schmidt & Son Co.
Hood Acres Well No. 5 - 1985

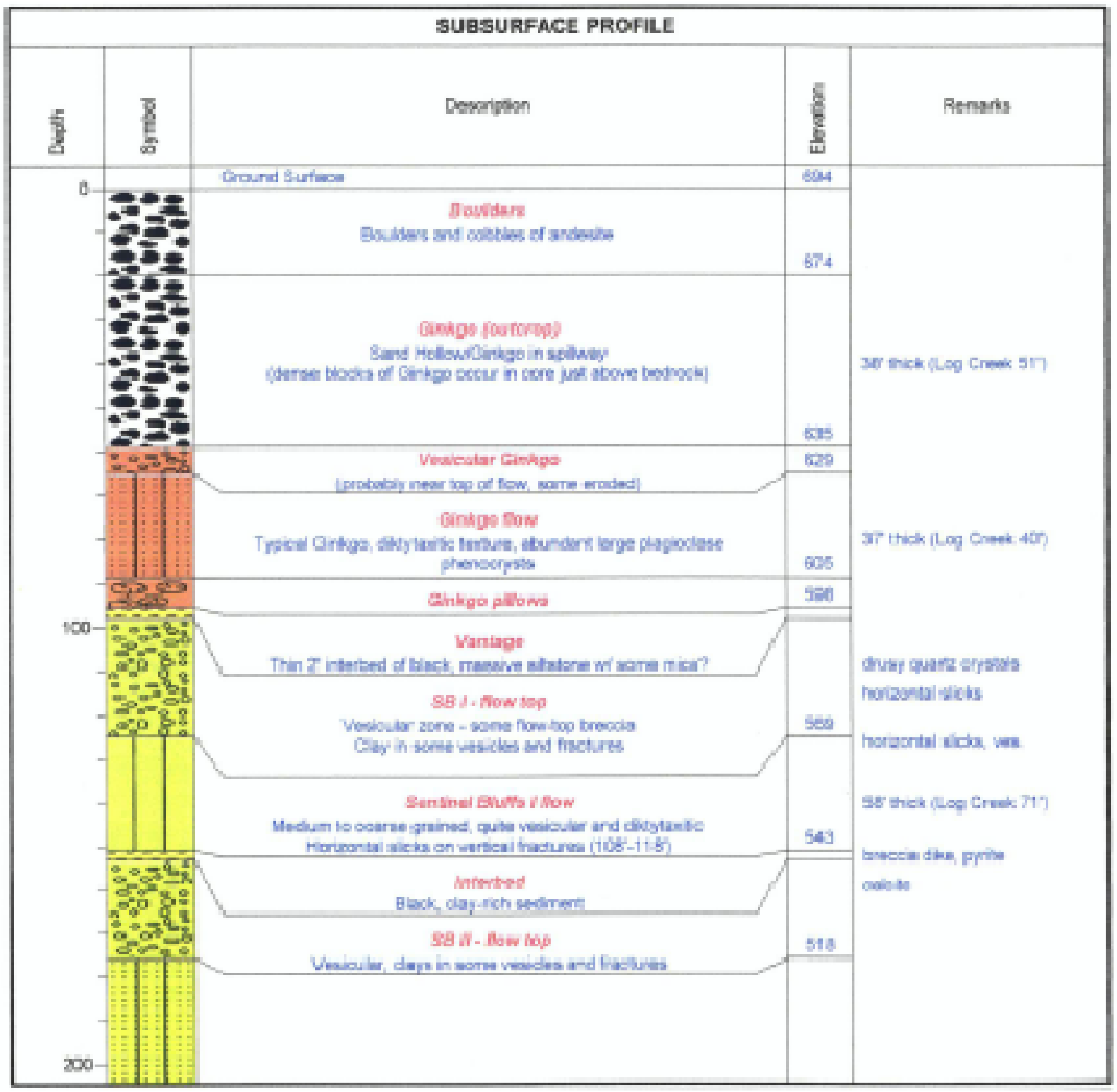


SCHNEIDER EQUIPMENT, INC.
21881 RIVER RD. N.E.
ST. PAUL, OR 97137
PH. (503) 633-2666

Geologic Log For Site CLAC 54800

NWIS Site ID: 452646122092301
OWRD Log ID: CLAC 54800
Well location: 01S/05E-35ABB01
Depth drilled, in feet below land surface: 584
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 693.69

Logged by: M. H. Beeson
Date drilled: 01/07/1999



Ground Surface 694

Boulders
Boulders and cobbles of andesite
674

Ginkgo (outcrop)
Sand Hollow/Ginkgo in spillway
(dense blocks of Ginkgo occur in core just above bedrock)
635
38' thick (Log Creek 51')

Vesicular GinKgo
(probably near top of flow, some eroded)
629

Ginkgo flow
Typical Ginkgo, diktytaxitic texture, abundant large plagioclase phenocrysts
605
37' thick (Log Creek 40')

Ginkgo pillows
598

Vantage
Thin 2' interbed of black, massive siltstone w/ some mica?
druzy quartz crystals
horizontal slicks

SB I - flow top
Vesicular zone – some flow-top breccia
Clay in some vesicles and fractures
569
horizontal slicks, ves.

Sentinel Bluffs I flow
Medium to coarse grained, quite vesicular and diktytaxitic
Horizontal slicks on vertical fractures (108'-118')
543
58' thick (Log Creek 71')
breccia dike, pyrite
calcite

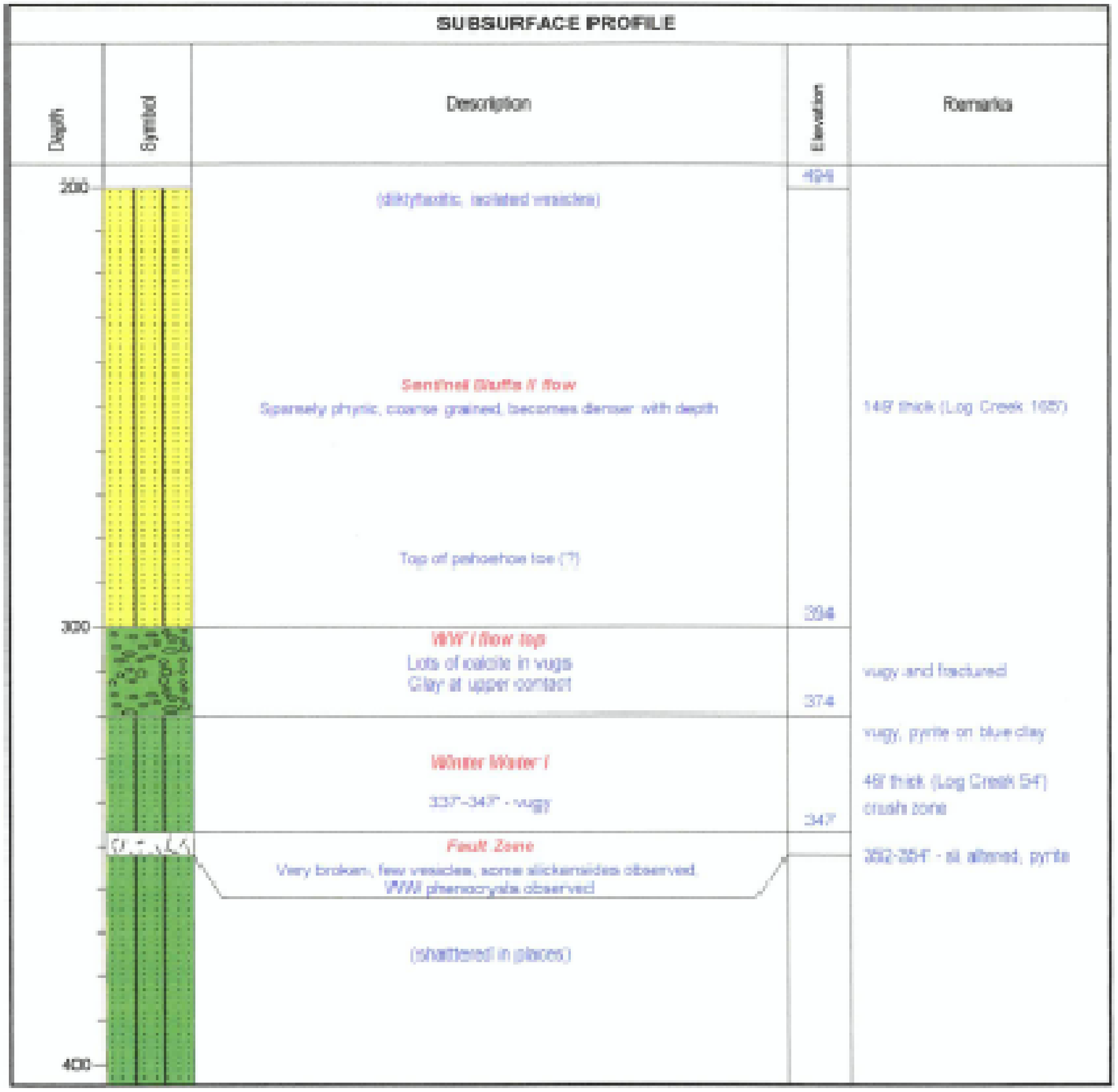
Interbed
Black, clay-rich sediment

SB II - flow top
Vesicular, clays in some vesicles and fractures
518

Geologic Log For Site CLAC 54800

NWIS Site ID: 452646122092301
OWRD Log ID: CLAC 54800
Well location: 01S/05E-35ABB01
Depth drilled, in feet below land surface: 584
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 693.69

Logged by: M. H. Beeson
Date drilled: 01/07/1999



(diktytaxitic, isolated vesicles)

Sentinel Bluffs II flow
Sparsely phyric, coarse grained, becomes denser with depth

Top of pahoehoe toe (?)

WW I flow top
Lots of calcite in vugs
Clay at upper contact

Winter Water I
337'-347' - vugy

Fault Zone
Very broken, few vesicles, some slickensides observed.
WW phenocrysts observed

(shattered in places)

148' thick (Log Creek 165')

vugy and fractured

vugy, pyrite on blue clay

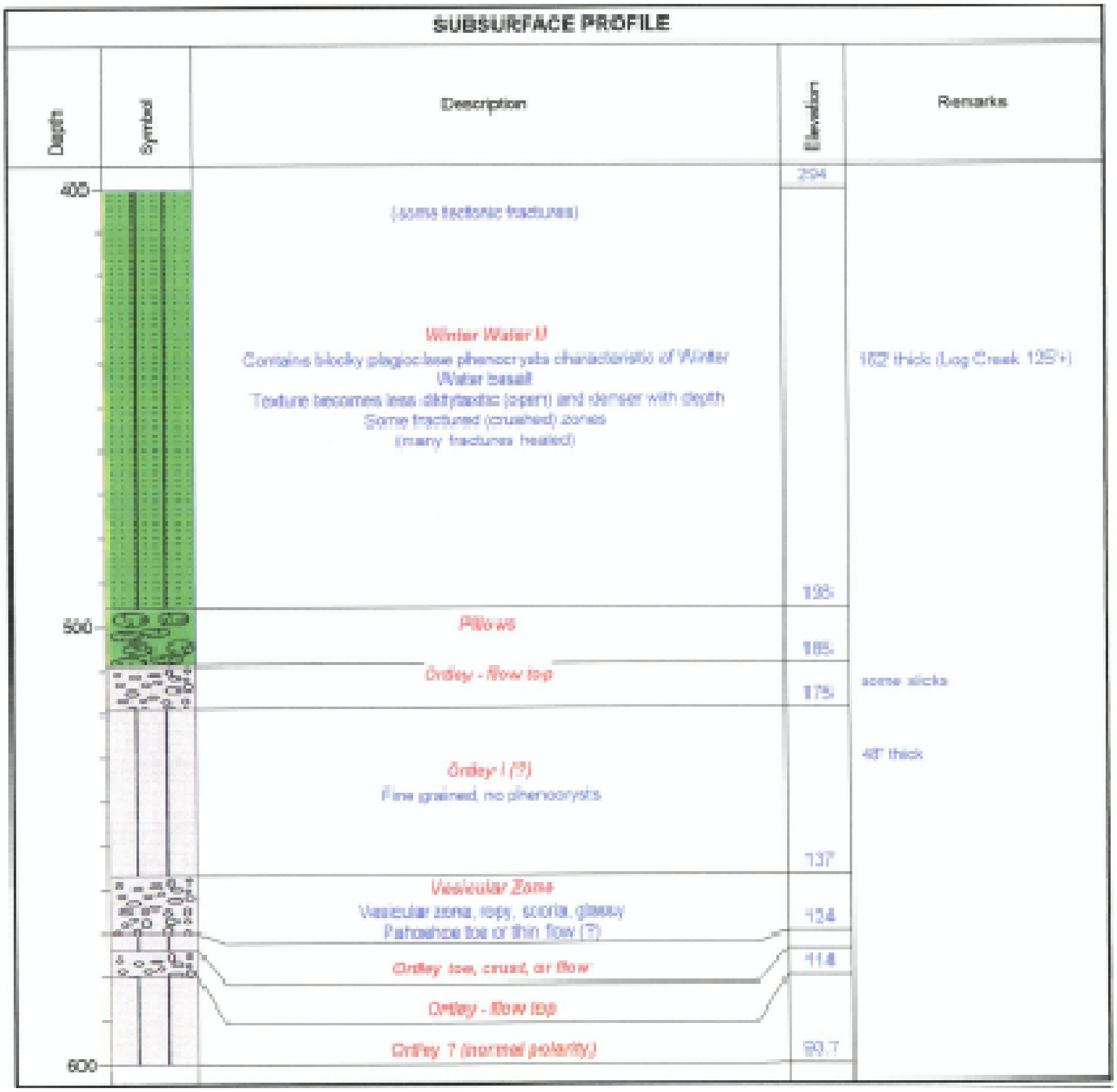
48' thick (Log Creek 54')
crush zone

352-354' - sl. altered, pyrite

Geologic Log For Site CLAC 54800

NWIS Site ID: 452646122092301
OWRD Log ID: CLAC 54800
Well location: 01S/05E-35ABB01
Depth drilled, in feet below land surface: 584
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 693.69

Logged by: M. H. Beeson
Date drilled: 01/07/1999



294

(some tectonic fractures)

Winter Water II
Contains blocky plagioclase phenocrysts characteristic of Winter Water basalt
Texture becomes less diktytaxitic (open) and denser with depth
Some fractured (crushed) zones
(many fractures healed)

162' thick (Log Creek 125'+)

195

Pillows

185

Ortley - flow top

some slicks

175

Ortley I (?)
Fine grained, no phenocrysts

48' thick

137

Vesicular Zone
Vesicular zone, ropy, scoria, glassy
Pahoehoe toe or thin flow (?)

124

114

Ortley toe, crust, or flow

Ortley - flow top

Ortley ? (normal polarity)

93.7

CLAC 56872

Clac 56872

Amended Well Report

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

WELL I.D. # L 43768
START CARD # 134870

(1) LAND OWNER Well Number ________
Name City of Portland
Address 1120 S.W. Fifth Ave.
City Portland State OR Zip 97204

(2) TYPE OF WORK
☒ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☒ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ________

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☒ Other Test Production

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 600 ft.
Explosives used ☐ Yes ☒ No Type ________ Amount ________

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds
24"	0	70	Cement	0	70	90 Sacks
20"	70	280	Cement	70	280	350 Sacks
15"	280	600				

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other ________
Backfill placed from ______ ft. to ______ ft. Material ________
Gravel placed from ______ ft. to ______ ft. Size of gravel ________

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	20	0	66	.375	☒	☐	☒	☐
	16	+1	280	.375	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Drive Shoe used ☐ Inside ☐ Outside ☐ None
Final location of shoe(s) ________

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ________
☐ Screens Type ________ Material ________

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☒ Pump ☐ Bailer ☐ Air ☒ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
950	—	—	96 hr.
1,350	140		72hr

Temperature of water 54° Depth Artesian Flow Found ________
Was a water analysis done? ☒ Yes By whom ________
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ________
Depth of strata: ________

(9) LOCATION OF WELL by legal description:
County Clackamas Latitude ________ Longitude ________
Township 1 N or [✓ S] Range 5 [✓ E] or W. WM.
Section 35 NE 1/4 NW 1/4
Tax Lot 1400 Lot ________ Block ________ Subdivision ________
Street Address of Well (or nearest address) Lower Headwater Road, Bull Run Watershed

(10) STATIC WATER LEVEL:
________ ft. below land surface. Date ________
Artesian pressure 70 lb. per square inch Date 6/15/01

(11) WATER BEARING ZONES:
Depth at which water was first found ________

From	To	Estimated Flow Rate	SWL
27	40	60	25
290	320	100	
510	550	500	67

(12) WELL LOG:
Ground Elevation ________

Material	From	To	SWL
Boulders Silt Sand	0	61	
Basalt Grey Slightly vesi	61	95	
Siltstone & Sandstone	95	100	
Basalt, Grey Top ves, w	100	150	
Basalt, Grey Aphyric	150	290	
Basalt, Grey Vesicular	290	320	
Basalt, Grey light aphyric	320	510	
Basalt, Grey Vesicular	510	550	
Basalt Grey fine grained	550	575	
Basalt, Grey Vesicular	575	585	
Sandstone Interbed	585	590	
Basalt Grey Vesicular	590	600	

RECEIVED
DEC 14 2001
WATER RESOURCES DEPT.
SALEM, OREGON

Date started 3-13-01 Completed 6-15-01

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number 1751
Signed ________ Date 12-11-01

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1464
Signed ________ Date 12/12/01

Clac
56872

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

WELL I.D. # L 43768
START CARD # 134870

(1) LAND OWNER
Well Number ____
Name City of Portland Water Bureau
Address 1120 SW Fifth Ave.
City Portland State OR Zip 97204

(2) TYPE OF WORK
☒ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☐ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other ____

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☒ Other Test Production

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☒ No Depth of Completed Well 600 ft.
Explosives used ☐ Yes ☒ No Type ____ Amount ____

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds
24"	0	60	Cement	0	60	90 Sacks
20"	60	280	Cement	60	280	350 Sacks
15"	60	600	—	—	—	—

How was seal placed Method ☐ A ☐ B ☒ C ☐ D ☐ E
☐ Other ____
Backfill placed from ____ ft. to ____ ft. Material ____
Gravel placed from ____ ft. to ____ ft. Size of gravel ____

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	20	0	60	.375	☒	☐	☒	☐
	16	+1	280	.375	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Drive Shoe used ☐ Inside ☐ Outside ☐ None
Final location of shoe(s) ____

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ____
☐ Screens Type ____ Material ____

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☒ Pump ☐ Bailer ☐ Air ☒ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
950	—	—	96 hr.
1,350	140		72 hr

Temperature of water 54° Depth Artesian Flow Found ____
Was a water analysis done? ☒ Yes By whom ____
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ____
Depth of strata: ____

(9) LOCATION OF WELL by legal description:
County Clackamas Latitude ____ Longitude ____
Township 1 N or [✓ S] Range 5 [✓ E] or W. WM
Section 35 NE 1/4 NW 1/4
Tax Lot 1400 Lot ____ Block ____ Subdivision ____
Street Address of Well (or nearest address) Lower Headwaters Rd, Bull Run Watershed

(10) STATIC WATER LEVEL:
____ ft. below land surface Date ____
Artesian pressure 70 lb. per square inch Date 6/15/01

(11) WATER BEARING ZONES:
Depth at which water was first found ____

From	To	Estimated Flow Rate	SWL
27	40	60	25
290	320	100	
510	550	500	67

(12) WELL LOG:
Ground Elevation ____

Material	From	To	SWL
Boulders, Silty sand	0	61	
Basalt, Gray, slightly vesic.	61	95	
Siltstone + Sandstone	95	100	
Basalt, Gray, [illegible]	100	150	
Basalt, Gray aphyric	150	290	
Basalt, gray, vesicular	290	320	
Basalt, light gray, aphyric	320	510	
Basalt, gray, vesicular	510	550	
Basalt, gray, fine grained	550	575	
Basalt, gray, vesicular	575	585	
Sandstone interbed	585	590	
Basalt, gray, vesicular	590	600	

RECEIVED
JUN 2 2 2001
WATER RESOURCES DEPT.
SALEM, OREGON

RECEIVED
AUG 2 9 2001
WATER RESOURCES DEPT.
SALEM, OREGON

Date started 3-13-01 Completed 6/15/01

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number 1751
Signed Gordon Durbin Date 6-19-01

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1444
Signed Date 6/19/01

ORIGINAL – WATER RESOURCES DEPARTMENT FIRST COPY – CONSTRUCTOR SECOND COPY – CUSTOMER

CLAC 60260

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

(WELL I.D.)# L 43768

(START CARD) # 164648

(1) OWNER:
Well Number PW-1
Name City of Portland
Address 1120 SW 5th Ave
City Portland State OR Zip 97204

(2) TYPE OF WORK
☐ New Well ☑ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☑ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

(4) PROPOSED USE:
☐ Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☑ Other test

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 650 ft.
Explosives used ☐ Yes ☑ No Type ______ Amount ______

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds
6"	600'	650'				

How was seal placed: Method ☐ A ☐ B ☐ C ☐ D ☐ E
☐ Other
Backfill placed from ___ ft. to ___ ft. Material ______
Gravel placed from ___ ft. to ___ ft. Size of gravel ______

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	NA				☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:	NA				☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s) ______

(7) PERFORATIONS/SCREENS:
☐ Perforations Method ______
☐ Screens Type ______ Material ______

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
NA						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☐ Air ☑ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
1000	flowing	------------	1 hr.

Temperature of water 54 F Depth Artesian Flow Found ______
Was a water analysis done? ☐ Yes By whom ______
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other ______
Depth of strata: ______

(9) LOCATION OF WELL by legal description:
County Clackamas Latitude ______ Longitude ______
Township 1 S Range 5 E WM.
Section 35 NE 1/4 NW 1/4
Tax Lot 1400 Lot ___ Block ___ Subdivision ___
Street Address of Well (or nearest address) Lower Headwater Rd, Bull Run Watershed

(10) STATIC WATER LEVEL:
______ ft. below land surface. Date ______
Artesian pressure 70 lb. per square inch. Date 6/21/04

(11) WATER BEARING ZONES:
Depth at which water was first found 103'

From	To	Estimated Flow Rate	SWL
600	611	960	
625	630	1000	

(12) WELL LOG:
Ground Elevation ______

Material	From	To	SWL
(reference original start # - 134870)			
Basalt (slightly vescular) - black w/ brown	600	611	
some pyrite			
Basalt (soft) - black w/ green	611	613	
Basalt (soft)-black w/ green; some yellow	613	625	
& white quartz			
Basalt -black, some green/red less quartz	625	630	
Basalt (Hard) - black/gray very few pieces	630	650	
vesicular, traces of gold			

RECEIVED
JUN 30 2004
WATER RESOURCES DEPT
SALEM, OREGON

Date started 5/25/04 Completed 5/28/04

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number 1523
Signed ______ Date 6/28/04

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

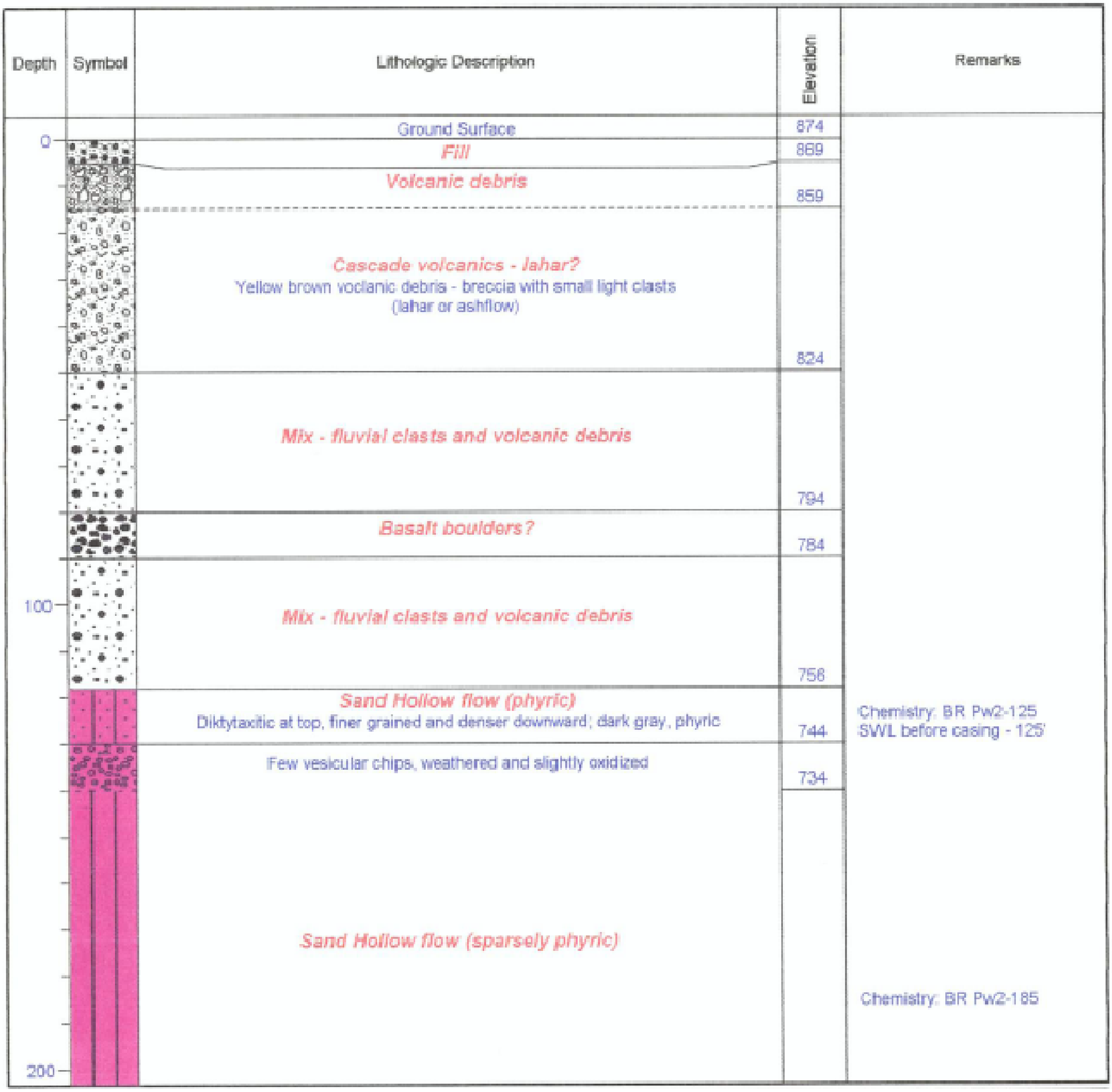
WWC Number [illegible]
Signed ______ Date [illegible]

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

Geologic Log For Site CLAC 58434

NWIS Site ID: 452646122090501
OWRD Log ID: CLAC 58434
Well location: 01S/05E-35ABA01
Depth drilled, in feet below land surface: 759.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 876.32

Logged by: M. H. Beeson
Date drilled: 11/01/2002

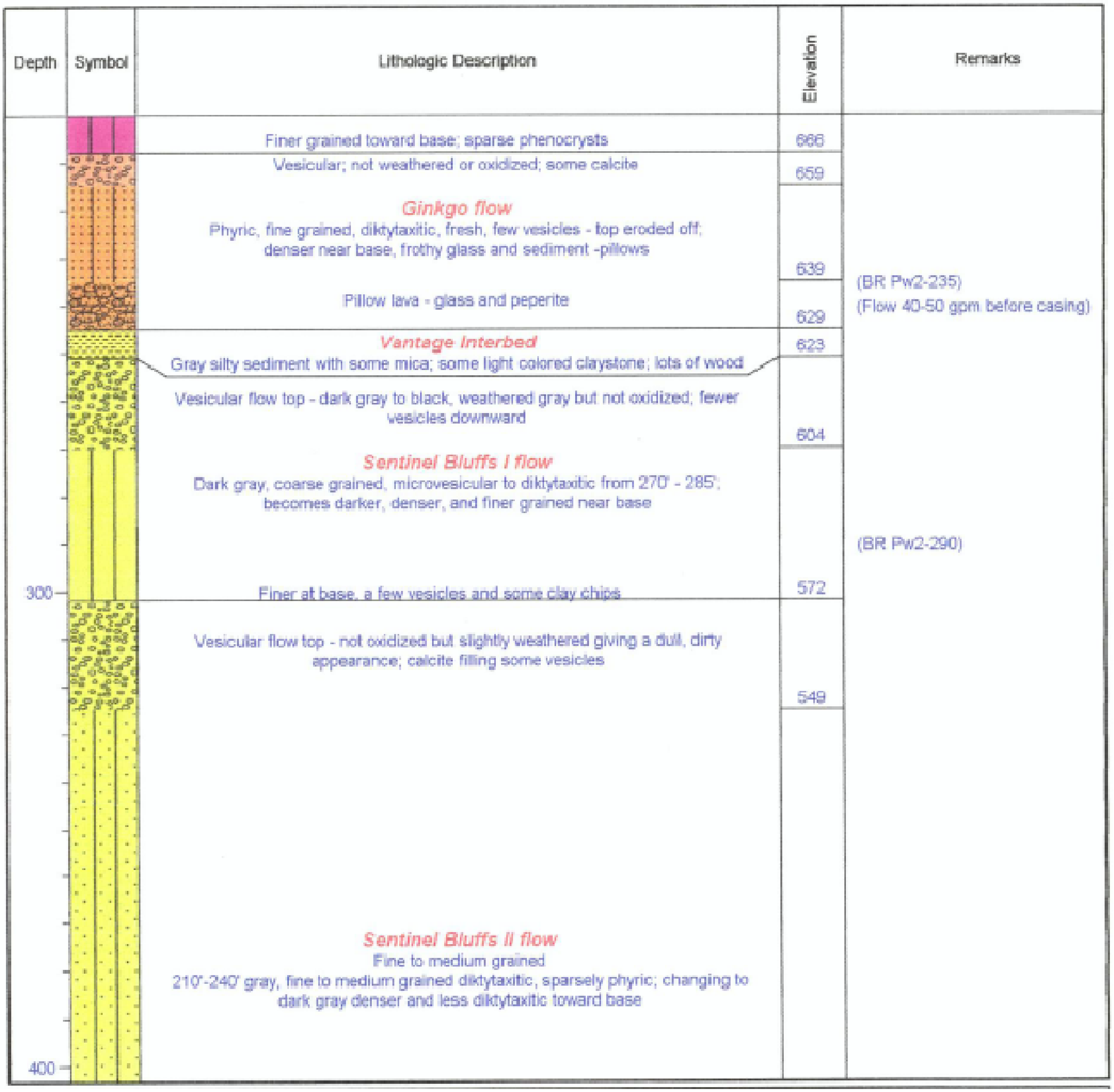


Depth	Symbol	Lithologic Description	Elevation	Remarks
		Ground Surface	874	
0		*Fill*	869	
		Volcanic debris	859	
		Cascade volcanics - Jahar? Yellow brown voclanic debris - breccia with small light clasts (lahar or ashflow)	824	
		Mix - fluvial clasts and volcanic debris	794	
		Basalt boulders?	784	
100		*Mix - fluvial clasts and volcanic debris*	756	
		Sand Hollow flow (phyric) Diktytaxitic at top, finer grained and denser downward; dark gray, phyric	744	Chemistry: BR Pw2-125 SWL before casing - 125'
		Few vesicular chips, weathered and slightly oxidized	734	
		Sand Hollow flow (sparsely phyric)		Chemistry: BR Pw2-185
200				

Geologic Log For Site CLAC 58434

NWIS Site ID: 452646122090501
OWRD Log ID: CLAC 58434
Well location: 01S/05E-35ABA01
Depth drilled, in feet below land surface: 759.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 876.32

Logged by: M. H. Beeson
Date drilled: 11/01/2002

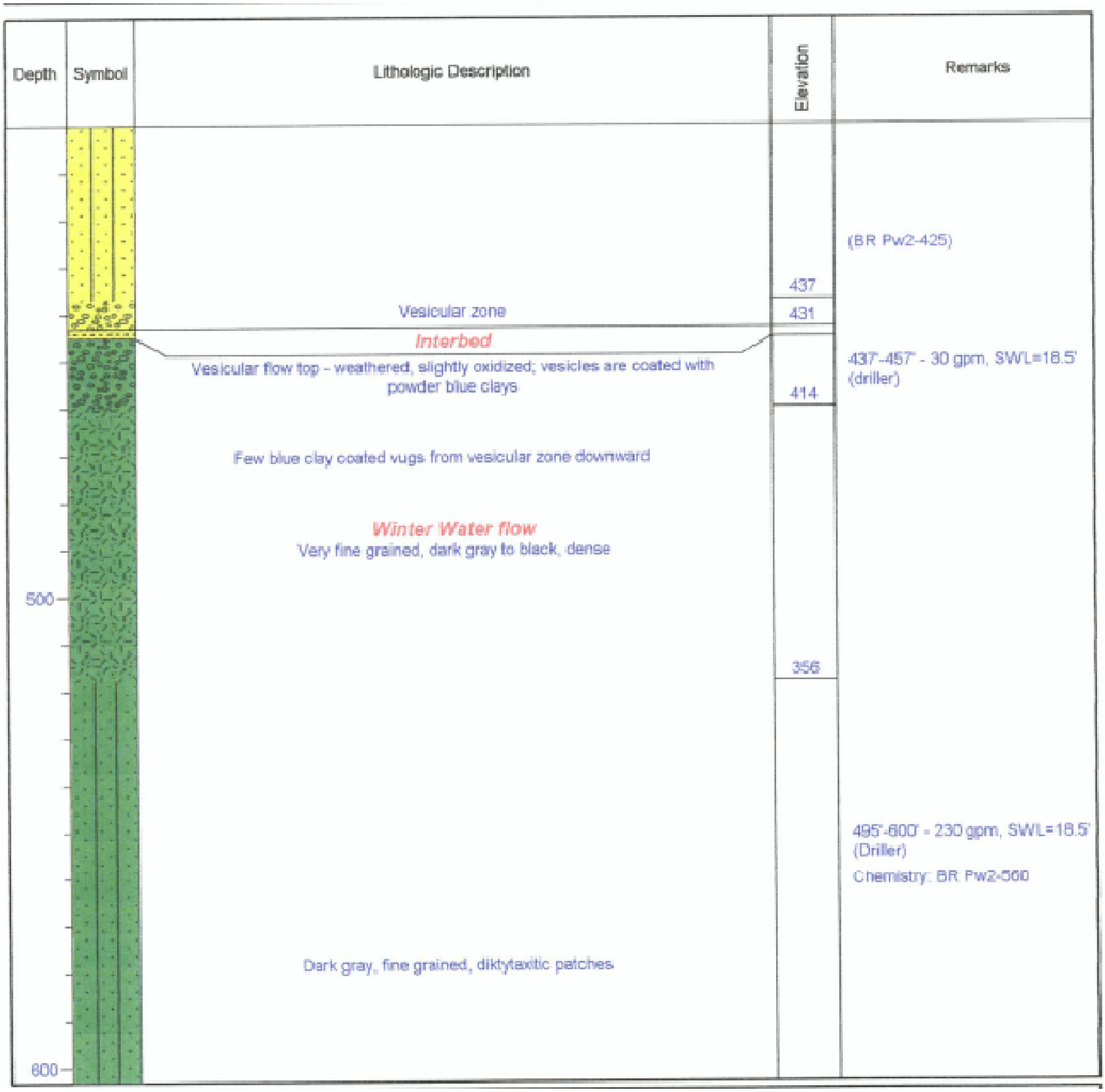


Depth	Symbol	Lithologic Description	Elevation	Remarks
		Finer grained toward base; sparse phenocrysts	666	
		Vesicular; not weathered or oxidized; some calcite	659	
		Ginkgo flow Phyric, fine grained, diktytaxitic, fresh, few vesicles - top eroded off; denser near base, frothy glass and sediment -pillows	639	
		Pillow lava - glass and peperite	629	(BR Pw2-235) (Flow 40-50 gpm before casing)
		Vantage Interbed Gray silty sediment with some mica; some light colored claystone; lots of wood	623	
		Vesicular flow top - dark gray to black, weathered gray but not oxidized; fewer vesicles downward	604	
300		*Sentinel Bluffs I flow* Dark gray, coarse grained, microvesicular to diktytaxitic from 270' - 285'; becomes darker, denser, and finer grained near base Finer at base, a few vesicles and some clay chips	572	(BR Pw2-290)
		Vesicular flow top - not oxidized but slightly weathered giving a dull, dirty appearance; calcite filling some vesicles	549	
400		*Sentinel Bluffs II flow* Fine to medium grained 210'-240' gray, fine to medium grained diktytaxitic, sparsely phyric; changing to dark gray denser and less diktytaxitic toward base		

Geologic Log For Site CLAC 58434

NWIS Site ID: 452646122090501
OWRD Log ID: CLAC 58434
Well location: 01S/05E-35ABA01
Depth drilled, in feet below land surface: 759.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 876.32

Logged by: M. H. Beeson
Date drilled: 11/01/2002



Vesicular zone

Interbed

Vesicular flow top - weathered, slightly oxidized; vesicles are coated with powder blue clays

Few blue clay coated vugs from vesicular zone downward

Winter Water flow

Very fine grained, dark gray to black, dense

Dark gray, fine grained, diktytaxitic patches

(BR Pw2-425)

437'-457' - 30 gpm, SWL=18.5' (driller)

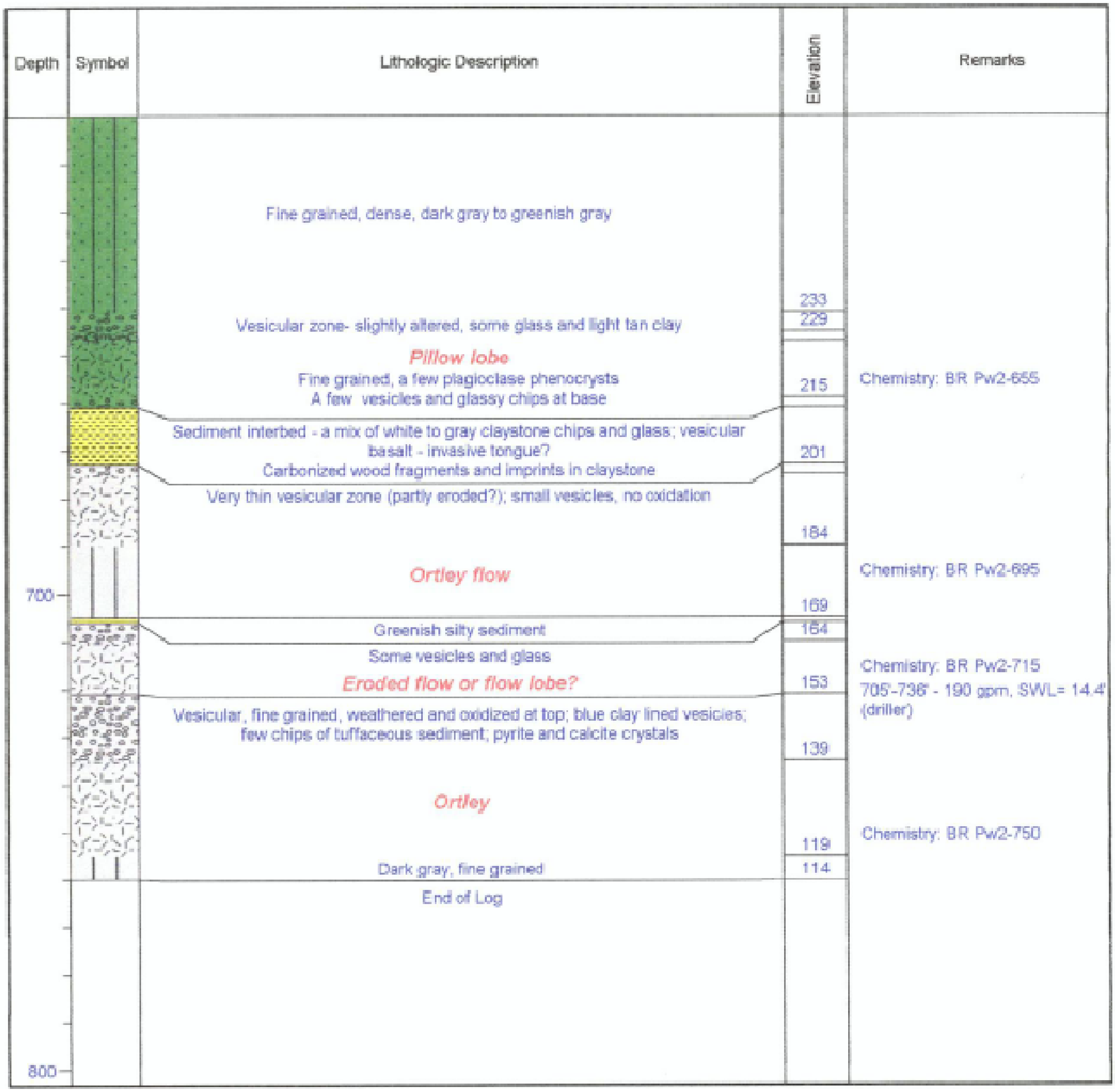
495'-600' - 230 gpm, SWL=18.5' (Driller)

Chemistry: BR Pw2-560

Geologic Log For Site CLAC 58434

NWIS Site ID: 452646122090501
OWRD Log ID: CLAC 58434
Well location: 01S/05E-35ABA01
Depth drilled, in feet below land surface: 759.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 876.32

Logged by: M. H. Beeson
Date drilled: 11/01/2002



Fine grained, dense, dark gray to greenish gray

233

229

Vesicular zone- slightly altered, some glass and light tan clay

Pillow lobe
Fine grained, a few plagioclase phenocrysts
A few vesicles and glassy chips at base

215

Chemistry: BR Pw2-655

Sediment interbed - a mix of white to gray claystone chips and glass; vesicular basalt - invasive tongue?
Carbonized wood fragments and imprints in claystone

201

Very thin vesicular zone (partly eroded?); small vesicles, no oxidation

184

Ortley flow

Chemistry: BR Pw2-695

169

Greenish silty sediment

164

Some vesicles and glass
Eroded flow or flow lobe?

153

Chemistry: BR Pw2-715
705'-738' - 190 gpm, SWL= 14.4'
(driller)

Vesicular, fine grained, weathered and oxidized at top; blue clay lined vesicles; few chips of tuffaceous sediment; pyrite and calcite crystals

139

Ortley

Chemistry: BR Pw2-750

119

Dark gray, fine grained

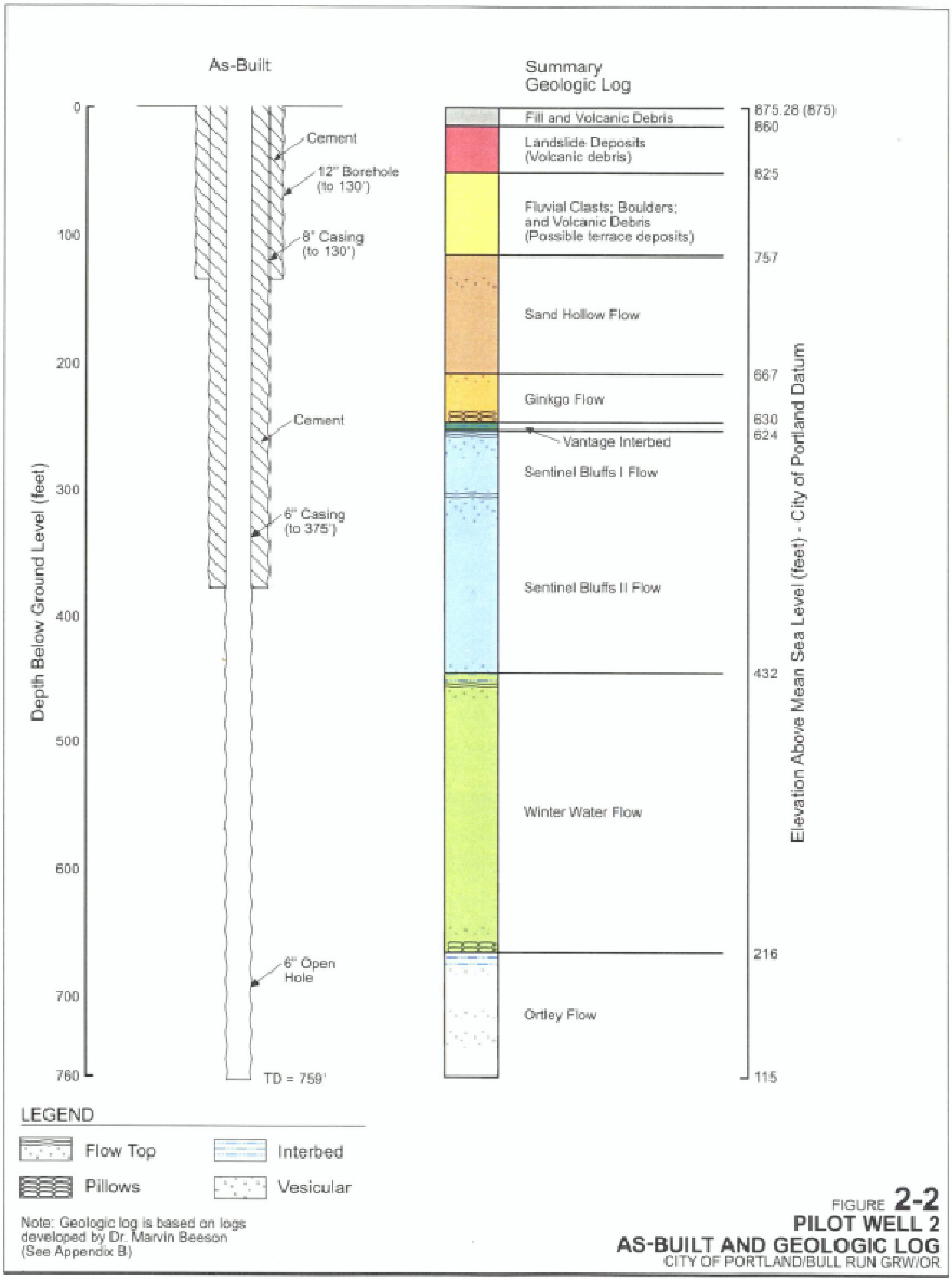
114

End of Log

Geologic Log For Site CLAC 58434

NWIS Site ID: 452646122090501
OWRD Log ID: CLAC 58434
Well location: 01S/05E-35ABA01
Depth drilled, in feet below land surface: 759.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 876.32

Logged by: M. H. Beeson
Date drilled: 11/01/2002



Note: Geologic log is based on logs developed by Dr. Marvin Beeson (See Appendix B)

FIGURE 2-2
PILOT WELL 2
AS-BUILT AND GEOLOGIC LOG
CITY OF PORTLAND/BULL RUN GRW/OR

CLAC 58435

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

(WELL I.D.)# L 58409

(START CARD) # 150220

(1) OWNER:
Well Number Pilot 1

Name City of Portland - Water Bureau

Address 1120 SW 5th Ave., Room 600

City Portland State OR Zip 97204

(2) TYPE OF WORK
☑ New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
☑ Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger

☐ Other

(4) PROPOSED USE:
☐ Domestic ☑ Community ☐ Industrial ☐ Irrigation

☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes ☑ No Depth of Completed Well 650 ft.

Explosives used ☐ Yes ☑ No Type Amount

HOLE			SEAL			
Diameter	From	To	Material	From	To	Sacks or pounds
16"	0	12	Cement	0		
12"	12	112			107	99 sacks
8"	112	270	Cement	107	266	70 sacks
6"	270	650				

How was seal placed: Method ☐ A ☐ B ☑ C ☐ D ☐ E

☑ Other 8" seal was pumped inside out from bottom up

Backfill placed from ft. to ft. Material

Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	8"	0	107	.250	☑	☐	☑	☐
	6"	+1	266	.250	☑	☐	☑	☐
					☐	☐	☐	☐
					☐	☐	☐	☐
Liner:					☐	☐	☐	☐
					☐	☐	☐	☐

Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
☐ Perforations Method

☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
						☐	☐
						☐	☐
						☐	☐
						☐	☐
						☐	☐

(8) WELL TESTS: Minimum testing time is 1 hour
☐ Pump ☐ Bailer ☑ Air ☑ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
500		650'	1 hr.
2,000			0.25 hrs

Temperature of water 54 F Depth Artesian Flow Found 340'

Was a water analysis done? ☐ Yes By whom

Did any strata contain water not suitable for intended use? ☐ Too little

☐ Salty ☐ Muddy ☐ Odor ☐ Colored ☐ Other

Depth of strata:

(9) LOCATION OF WELL by legal description:
County Clackamas Latitude Longitude

Township 1 S Range 5 E WM.

Section 35 NW 1/4 NW 1/4

Tax Lot Lot Block Subdivision

Street Address of Well (or nearest address) Bull Run Watershed, Dam #2 Headwords

(10) STATIC WATER LEVEL:
ft. below land surface. Date

Artesian pressure 56 lb. per square inch. Date 12/11/02

(11) WATER BEARING ZONES:
Depth at which water was first found

From	To	Estimated Flow Rate	SWL
187	240	30 GPM	64
325	340	100 GPM	56
340	395	Flowing 150 GPM	
395	650	500 GPM	

(12) WELL LOG:
Ground Elevation

Material	From	To	SWL
See Attached Sheet			

RECEIVED

JAN 08 2003

WATER RESOURCES DEPT
SALEM OREGON

Date started 10-14-02 Completed 12/11/02

(unbonded) Water Well Constructor Certification:

I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number 1751

Signed Date 12-19-02

(bonded) Water Well Constructor Certification:

I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number 1464

Signed Date 12-19-02

ORIGINAL & FIRST COPY-WATER RESOURCES DEPARTMENT SECOND COPY-CONSTRUCTOR THIRD COPY-CUSTOMER

CLAC 58435

Geo-Tech Explorations, Inc.
19700 SW Teton
Tualatin, OR 97062
Ph: (503) 692-6400, Fax: (503) 692-4759

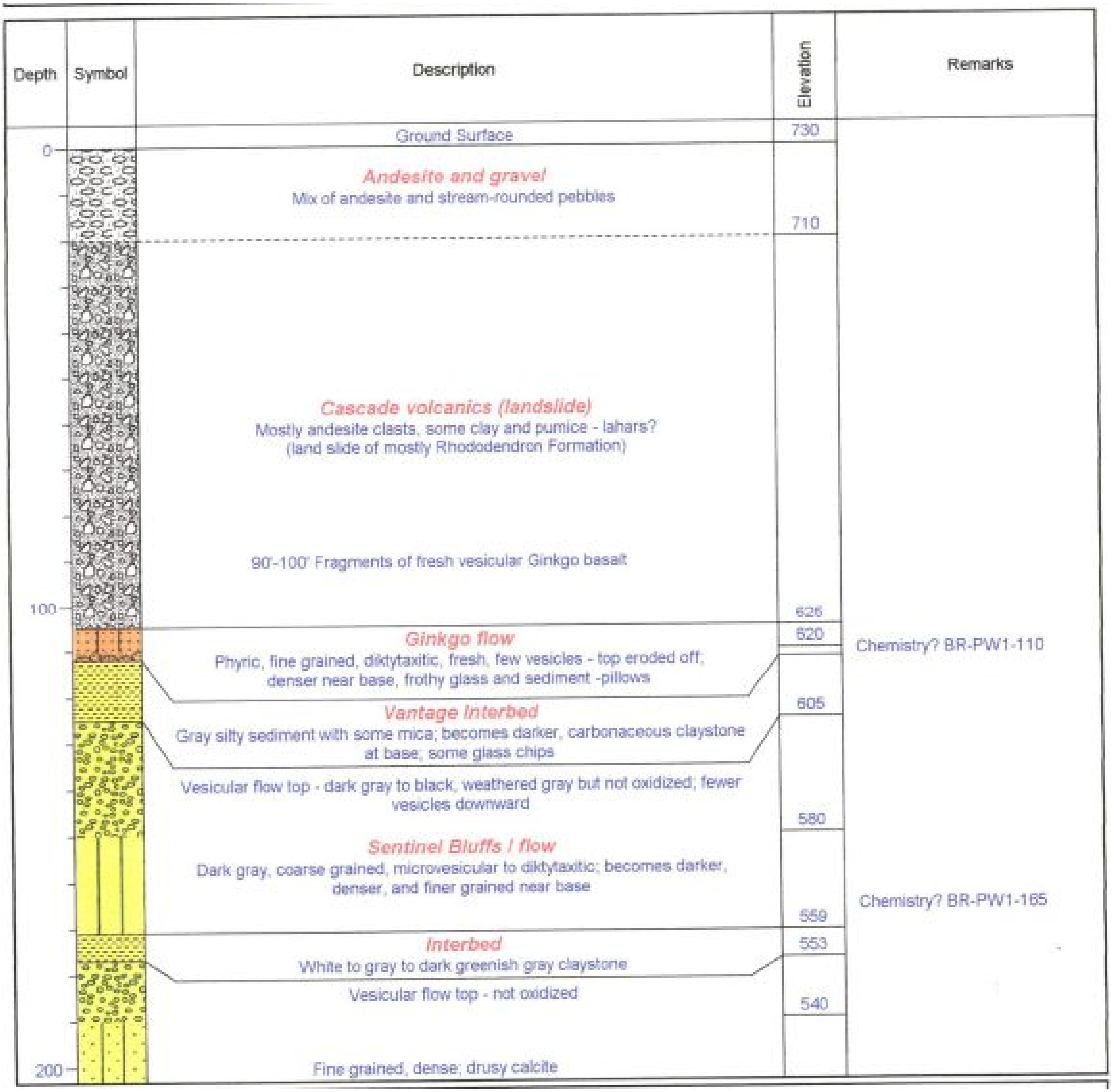
Well Name: Bull Run Pilot Well # 1
Start Card #: 150220
Label #: L58409

Material Description	From:	To:
Silty Gravels	0	9
Large Basalt Boulder	9	17
Gravels, small to large, silty	17	28
Red Gravelly clay	28	31
Blue gray clay	31	38
gravels small to medium	38	58
Gray sandstone	58	65
Red Gravelly clay	65	102
good basalt gray medium	102	125
Grey medium basalt with light gray claystone	125	130
gray- black basalt, hard	130	168
gray basalt, mudium with sand-brown	168	171
green sandstone with gray siltstone	171	187
Basalt medium gray	187	325
Weathered Basalt with green sandstone	325	340
Black, gray Basalt	340	395
Basalt, fractured	395	402
Basalt, gray medium	402	450
Basalt gray, medium, fractured	450	452
Basalt, gray medium	452	458
Basalt gray, medium, fractured	458	475
Basalt, gray medium	475	512
Fractured vesicular basalt with pyrite	512	520
gray basalt medium	520	531
dark gray seimentary rock with light gray clay	531	538
Weathered Basalt with brown sedimentary rock	538	545
Basalt gray, medium	545	580
Basalt, gray, very hard	580	592
Basalt, gray, medium	592	594
Basalt, gray, very hard	594	603
Basalt, gray, fractured, medium	603	605
Basalt, gray, very hard	605	613
Vesicular, fractured Basalt	613	633
Basalt, gray, medium	633	649.5

Geologic Log For Site CLAC 58435

NWIS Site ID: 452650122091701
OWRD Log ID: CLAC 58435
Well location: 01S/05E-26DCC01
Depth drilled, in feet below land surface: 649.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 731.64

Logged by: M. H. Beeson
Date drilled: 10/14/2002

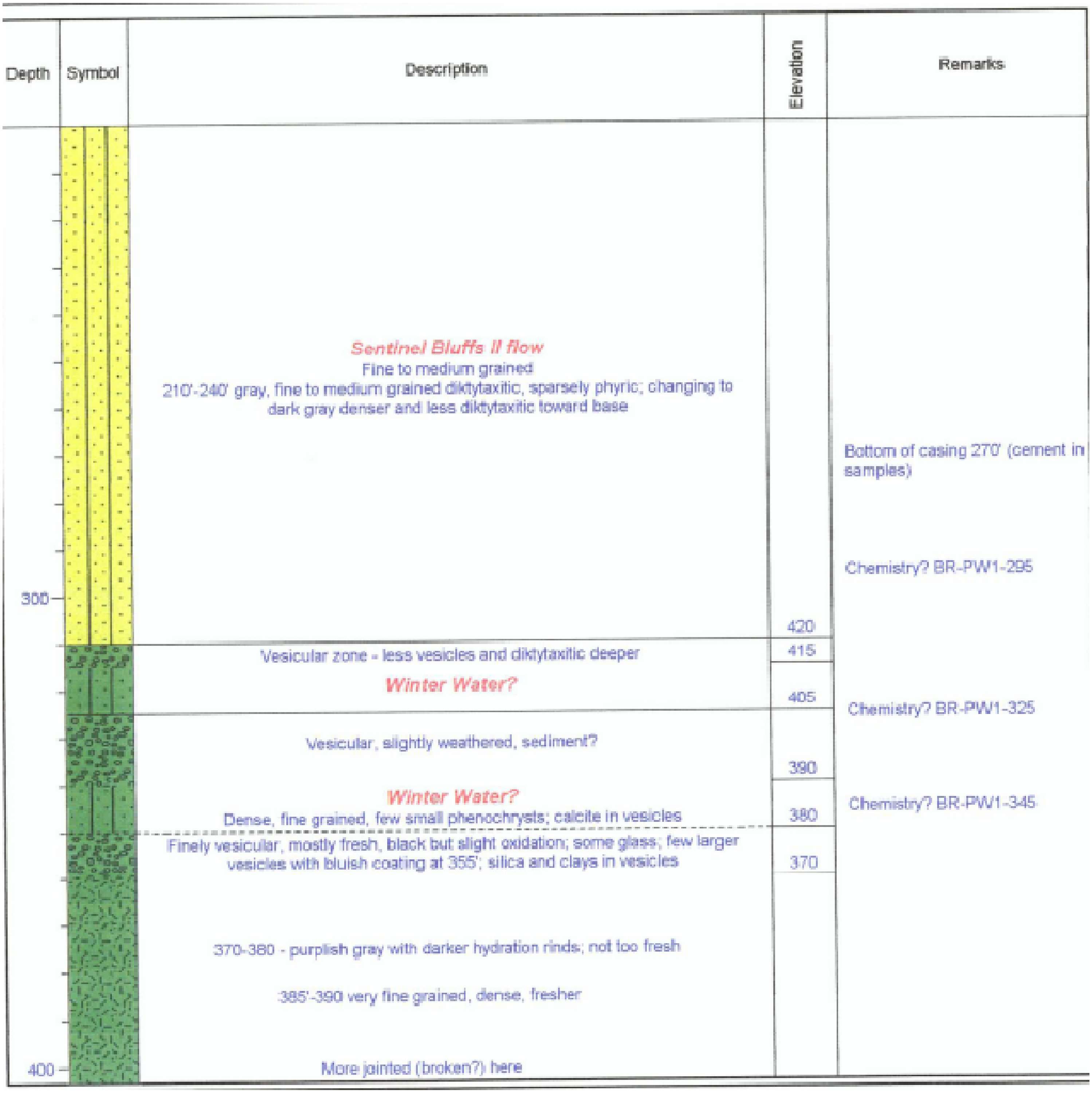


Description	Elevation	Remarks
Ground Surface	730	
Andesite and gravel Mix of andesite and stream-rounded pebbles	710	
Cascade volcanics (landslide) Mostly andesite clasts, some clay and pumice - lahars? (land slide of mostly Rhododendron Formation) 90'-100' Fragments of fresh vesicular Ginkgo basalt	626	
Ginkgo flow Phyric, fine grained, diktytaxitic, fresh, few vesicles - top eroded off; denser near base, frothy glass and sediment -pillows	620	Chemistry? BR-PW1-110
Vantage Interbed Gray silty sediment with some mica; becomes darker, carbonaceous claystone at base; some glass chips	605	
Vesicular flow top - dark gray to black, weathered gray but not oxidized; fewer vesicles downward	580	
Sentinel Bluffs I flow Dark gray, coarse grained, microvesicular to diktytaxitic; becomes darker, denser, and finer grained near base	559	Chemistry? BR-PW1-165
Interbed White to gray to dark greenish gray claystone	553	
Vesicular flow top - not oxidized	540	
Fine grained, dense; drusy calcite		

Geologic Log For Site CLAC 58435

NWIS Site ID: 452650122091701
OWRD Log ID: CLAC 58435
Well location: 01S/05E-26DCC01
Depth drilled, in feet below land surface: 649.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 731.64

Logged by: M. H. Beeson
Date drilled: 10/14/2002



Depth | Symbol | Description | Elevation | Remarks

Sentinel Bluffs II flow
Fine to medium grained
210'-240' gray, fine to medium grained diktytaxitic, sparsely phyric; changing to dark gray denser and less diktytaxitic toward base

Bottom of casing 270' (cement in samples)

Chemistry? BR-PW1-295

300

420

Vesicular zone - less vesicles and diktytaxitic deeper
Winter Water?

415

405

Chemistry? BR-PW1-325

Vesicular, slightly weathered, sediment?

390

Winter Water?
Dense, fine grained, few small phenochrysts; calcite in vesicles

380

Chemistry? BR-PW1-345

Finely vesicular, mostly fresh, black but slight oxidation; some glass; few larger vesicles with bluish coating at 355'; silica and clays in vesicles

370

370-380 - purplish gray with darker hydration rinds; not too fresh

385'-390 very fine grained, dense, fresher

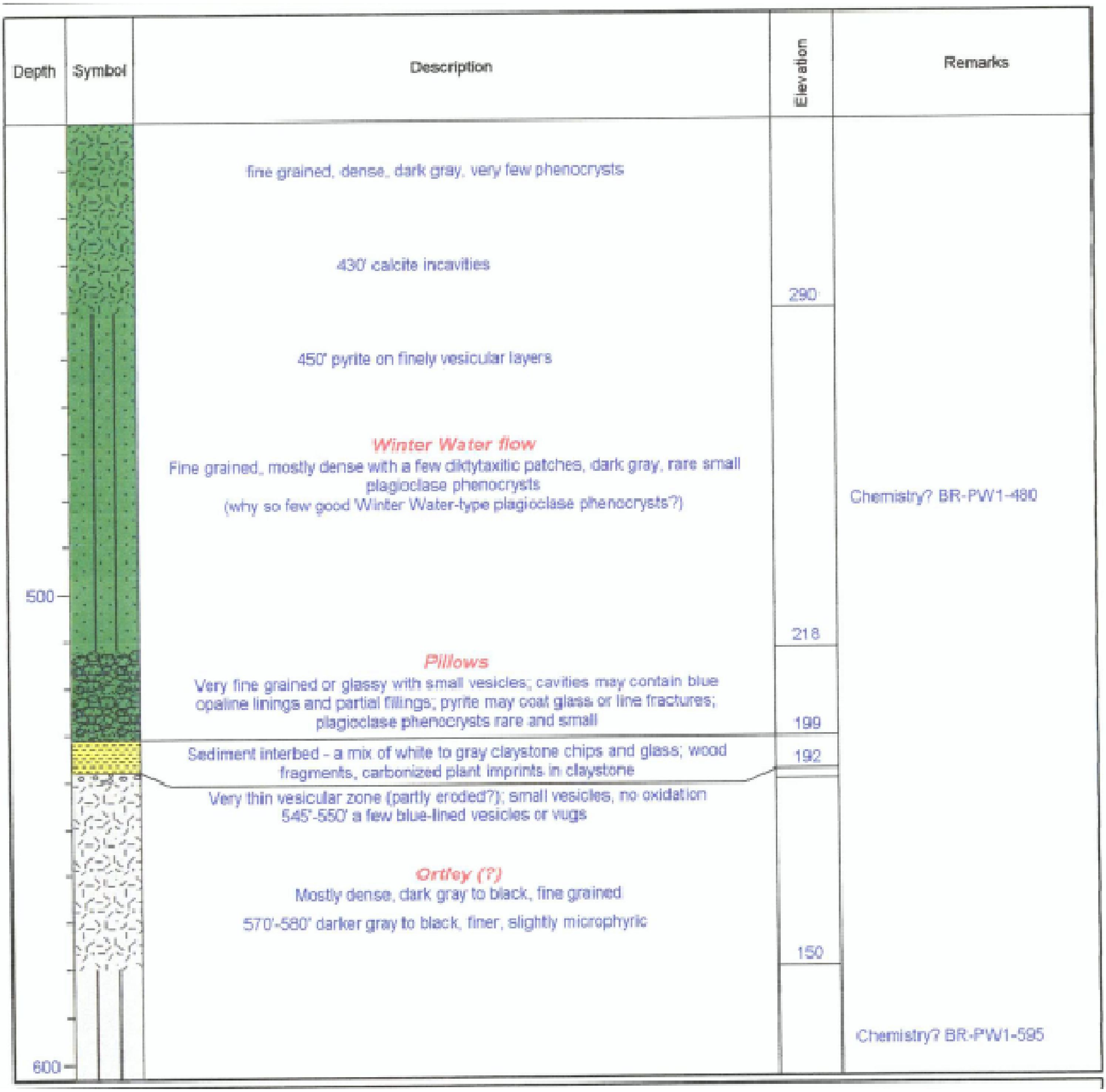
More jointed (broken?) here

400

Geologic Log For Site CLAC 58435

NWIS Site ID: 452650122091701
OWRD Log ID: CLAC 58435
Well location: 01S/05E-26DCC01
Depth drilled, in feet below land surface: 649.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 731.64

Logged by: M. H. Beeson
Date drilled: 10/14/2002



fine grained, dense, dark gray, very few phenocrysts

430' calcite incavities

450' pyrite on finely vesicular layers

Winter Water flow
Fine grained, mostly dense with a few diktytaxitic patches, dark gray, rare small plagioclase phenocrysts
(why so few good Winter Water-type plagioclase phenocrysts?)

Chemistry? BR-PW1-480

Pillows
Very fine grained or glassy with small vesicles; cavities may contain blue opaline linings and partial fillings; pyrite may coat glass or line fractures; plagioclase phenocrysts rare and small

Sediment interbed - a mix of white to gray claystone chips and glass; wood fragments, carbonized plant imprints in claystone

Very thin vesicular zone (partly eroded?); small vesicles, no oxidation
545'-550' a few blue-lined vesicles or vugs

Ortley (?)
Mostly dense, dark gray to black, fine grained

570'-580' darker gray to black, finer, slightly microphyric

Chemistry? BR-PW1-595

Geologic Log For Site CLAC 58435

NWIS Site ID: 452650122091701
OWRD Log ID: CLAC 58435
Well location: 01S/05E-26DCC01
Depth drilled, in feet below land surface: 649.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 731.64

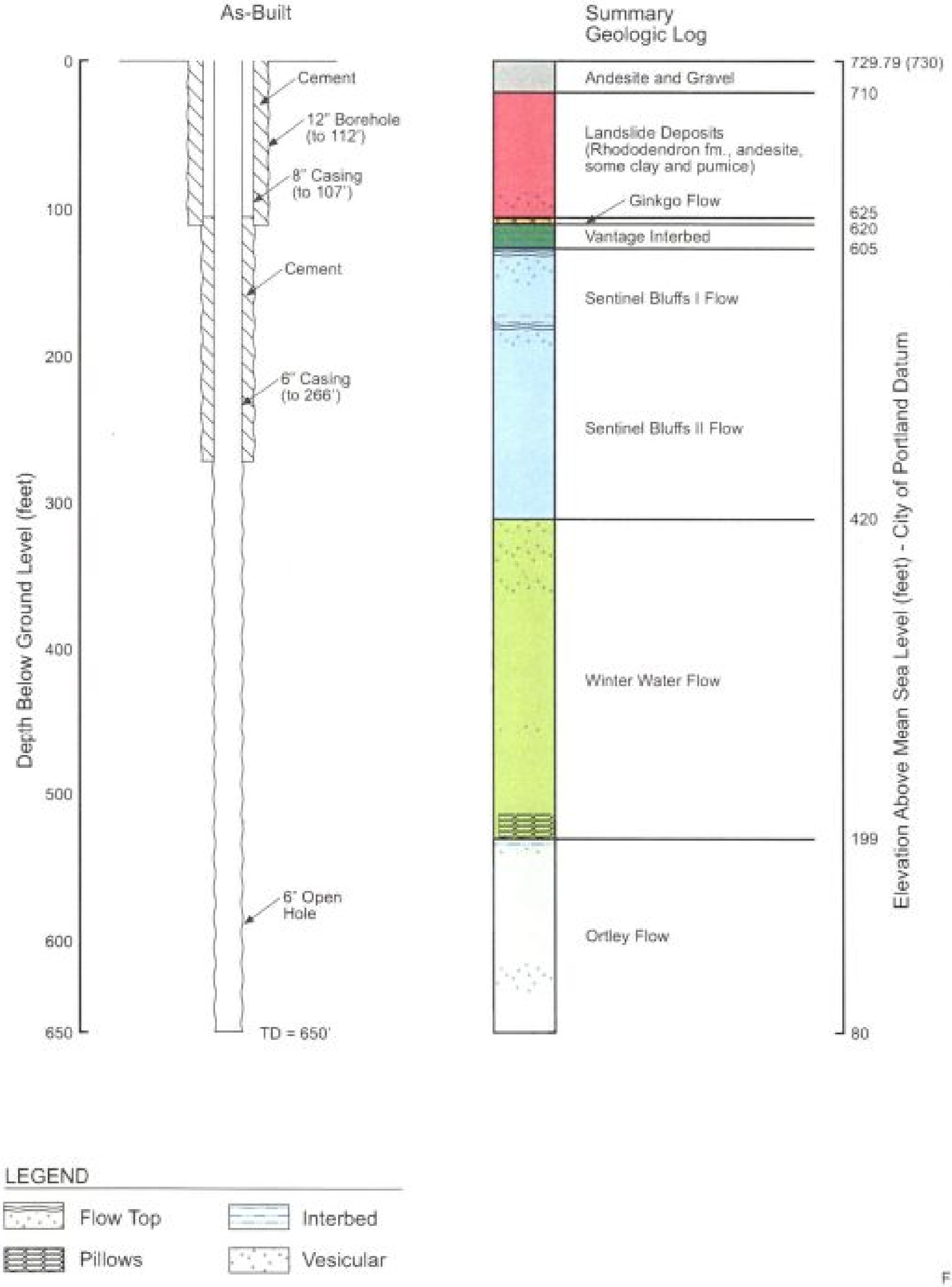
Logged by: M. H. Beeson
Date drilled: 10/14/2002

Depth	Symbol	Description	Elevation	Remarks
		Dark gray, dense; some blue coatings on irregular cavities	117	
		Vesicular, fine grained, not weathered or oxidized; blue clay lined cavities	100	
		Ortley (?)	90	
		Gray to dark gray, slightly diktytaxitic in patches	80	Chemistry? BR-PW1-650
700				
800				

Geologic Log For Site CLAC 58435

NWIS Site ID: 452650122091701
OWRD Log ID: CLAC 58435
Well location: 01S/05E-26DCC01
Depth drilled, in feet below land surface: 649.5
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 731.64

Logged by: M. H. Beeson
Date drilled: 10/14/2002



Note: Geologic log is based on logs developed by Dr. Marvin Beeson (See Appendix B)

FIGURE **2-1**

PILOT WELL 1

AS-BUILT AND GEOLOGIC LOG

CITY OF PORTLAND/BULL RUN GRW/OR

FORM NO. 9-1904-A
Revised February 1987

MULT
56740

Coded by ____________

Checked by ____________

Entered by ____________

File Code 01S/04E-01BDA

Date ____________

PDX Well 700358

U.S. DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

GROUND-WATER SITE SCHEDULE
General Site Data

STATE OF OREGON
DOGAMI
Howard Canyon
Geothermal Well

453055122153101

AGENCY CODE (C4) [redacted]

SITE ID (C1) [redacted]

PROJECT NO. (C5) 47411-16800

STATION NAME (C12) [redacted]

LATITUDE (C9) [redacted]

LONGITUDE (C10) [redacted]

LAT-LONG ACCURACY (C11) S F T M (sec, 5 sec, 10 sec, min)

DISTRICT (C6) [redacted]

STATE (C7) [redacted]

COUNTY or TOWN (C8) MULTNOMAH

County code [redacted]

LAND NET (C13) ¼ ¼ ¼ S section T township R range merid

LOCATION MAP (C14) WASHOUGAL

MAP SCALE (C15) 24000

ALTITUDE (C16) 570.00

METHOD OF MEASUREMENT (C17) A altimeter, L level, [✓ M map]

ACCURACY (C18) 10

HYDROLOGIC UNIT CODE (C20)

DRAINAGE BASIN CODE (C801)

TOPOGRAPHIC SETTING (C19) A alluvial fan, B playa, C stream channel, D depression, E dunes, F flat, G flood plain, H hilltop, K sinkhole, L lake or swamp, M mangrove swamp, O offshore, P pediment, S hillside, T terrace, U undulating, V valley flat, W upland draw

AGENCY USE (C803) [redacted] active, inactive, inventory only

DATE INVENTORIED (C711) __ month - __ day - 19__ year

STATION TYPE (C802) (Place a 'Y' in the appropriate box) [redacted] well

DATA TYPE (C804) (Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box) WL cont., WL int., QW cont., QW int., [redacted] State water use

INSTRUMENTS (C805) (Place a 'Y' in the appropriate box): digital recorder, graphic recorder, telemetry land line, telemetry radio, telemetry satellite, AHDAS, [redacted] deflection meter, bubble gage, [redacted] CR type recorder, weighing rain gage, tipping bucket rain gage

REMARKS (C806)

MULT
56740

900358

DRILLING LOG DIVISION DOGAMI INSTALLATION Howard Canyon SHEET 1 OF 5 SHEETS

1. PROJECT Corbett-Moffett
2. LOCATION (Coordinates or Station) 1S/4E/1 Bcenter
3. DRILLING AGENCY West Coast Drilling
4. HOLE NO. (As shown on drawing title and file number) 1S/4E/1Bcenter
5. NAME OF DRILLER Byron Stadeli
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 35'
8. DEPTH DRILLED INTO ROCK 293'
9. TOTAL DEPTH OF HOLE 500'
10. SIZE AND TYPE OF BIT 6" Hammer
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Schramm 64
13. TOTAL CORE RECOVERY FOR BORING — %
14. TOTAL NUMBER OF CORE BOXES —
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 10/16/81 COMPLETED 10/21/81
17. ELEVATION TOP OF HOLE 570'
18. NAME OF GEOLOGIST M Wilkening
19. SIGNATURE OF GEOLOGIST M Wilkening

PENET. RATE (ft/hr)	DEPTH (ft)	LITHOLOGY	CLASSIFICATION OF MATERIAL (DESCRIPTION)	WATER LEVEL (DATE)	FLOW-LINE TEMP. IN	FLOW-LINE TEMP. OUT	H₂O (gpm)	TIME / DATE	REMARKS: CASING, CORING POINTS, BOTTOM-HOLE TEMP., WATER SAMPLING AND TEMP. POINTS
	10 20 30		0-35 Vericolored Sand + Gravel subangular-well rounded clasts of Basalt, Quartzite, Vocanoclastics + exotics. Poorly consolidated water bearing zone		SG	0-35		10/16	Water 1st encountered appx 35'. Zone cased off + no water in hole after drilling.
	40		35-50' Very muddy orangish brown sandstone. Moderately consolidated. subangular-rounded basalt, chert + quartzite grains-sized fine-coarse.	35' 10/16	35 SC	35-50			
	50 60 70 80		50-90' Orangish brown-greenish grey sandy mudstone Sand as above decrs from 20-10% of sample. Moderately consolidated		50 CS	50-207		10/17	
	90 100		90-207 slightly sandy clay/claystone.						CSG @ 97'

1981

MULT
56740

DRILLING LOG

DIVISION DOGAMI

INSTALLATION Howard Canyon

SHEET 2 OF 5 SHEETS

1. PROJECT Howard Canyon
2. LOCATION (Coordinates or Station) 1S/4E/1 B center
3. DRILLING AGENCY West Coast Drilling
4. HOLE NO. (As shown on drawing title and file number) 1S/4E/1 Bcen
5. NAME OF DRILLER R. Stadeli
6. DIRECTION OF HOLE

☒ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN 35'
8. DEPTH DRILLED INTO ROCK 293
9. TOTAL DEPTH OF HOLE 500
10. SIZE AND TYPE OF BIT 6" Hammer
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Schramm 40
13. TOTAL CORE RECOVERY FOR BORING %
14. TOTAL NUMBER OF CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 10/16/ COMPLETED 10/21
17. ELEVATION TOP OF HOLE 570'
18. NAME OF GEOLOGIST M Wilkening
19. SIGNATURE OF GEOLOGIST M. Wilkening

PENET. RATE (ft/hr)	DEPTH (ft)	LITHOLOGY	CLASSIFICATION OF MATERIAL (DESCRIPTION)	WATER LEVEL (DATE)	FLOW-LINE TEMP. IN	FLOW-LINE TEMP. OUT	H₂O (gpm)	TIME / DATE	REMARKS: CASING, CORING POINTS, BOTTOM-HOLE TEMP., WATER SAMPLING AND TEMP. POINTS
	100		90-207' Slightly sandy clay/claystone Color varies thru column. Sand - med-fine grain, subrounded to well rounded, grains of qtz, tr. amts mica. % of Sand decrs w/ depth, 5-1%			CS (cont)			
	110		110-120 Color greyish pink						
	120		120-130 ~~Greenish grey~~ grey						
	130		130-170 Greenish brown grey						
	140								
17 min/10'	150								
	160								
	170		170-180 Reddish brown						
	180		180-190 Yellowish brown						
	190	Missing							190-200 Sample missing - Geol absent
	200								

1961

MULT 56710

DRILLING LOG

DIVISION DOGAMI

INSTALLATION Howard Canyon

SHEET 3 OF 5 SHEETS

1. PROJECT Corbett Moffett
2. LOCATION (Coordinates or Station) 1S/4E/1B center
3. DRILLING AGENCY West Coast Drilling
4. HOLE NO. (As shown on drawing title and file number) 1S/4E/1B center
5. NAME OF DRILLER B. Stadali
6. DIRECTION OF HOLE ☑ VERTICAL ☐ INCLINED ______ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 35'
8. DEPTH DRILLED INTO ROCK 293
9. TOTAL DEPTH OF HOLE 500'
10. SIZE AND TYPE OF BIT 6" hammer
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Schramm 62
13. TOTAL CORE RECOVERY FOR BORING %
14. TOTAL NUMBER OF CORE BOXES —
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 10/16 COMPLETED 10/21
17. ELEVATION TOP OF HOLE 570
18. NAME OF GEOLOGIST M. Wilkening
19. SIGNATURE OF GEOLOGIST M. Wilkening

PENET. RATE (ft/hr)	DEPTH (ft)	LITHOLOGY	CLASSIFICATION OF MATERIAL (DESCRIPTION)	WATER LEVEL (DATE)	FLOW-LINE TEMP. IN	FLOW-LINE TEMP. OUT	H₂O (gpm)	TIME / DATE	REMARKS, CASING, CORING POINTS, BOTTOM-HOLE TEMP., WATER SAMPLING AND TEMP. POINTS
	200		90-207' Slightly Sandy Clay/Claystone.						
			207-220 Basalt med gray, vesicular, slightly glassy w/ phenos of Plag (tr.)	—					
	210				RC	207-		500	
	220		220-250 Basalt - dk grey more massive, less glassy Plag phenos more pronounced.						
	230		230-240 - Contaminated sample.						
			Possibly a flow top @ 239'(!)						
	240								
	250		250-341 Basalt, dk grey massive phenos of ~~basalt~~ Plag + mafics present in trace amts						
	260								
	270								
	280							10/20	
	290								
	300								

1981

MULT
56740

DRILLING LOG

DIVISION DOGAMI

INSTALLATION Howard Canyon

SHEET 4 OF 5 SHEETS

1. PROJECT Corbett-Moffett
2. LOCATION (Coordinates or Station) 1S/4E/1B center
3. DRILLING AGENCY West Coast Drilling
4. HOLE NO. (As shown on drawing title and file number) 1S/4E/1B center
5. NAME OF DRILLER B. Stadeli
6. DIRECTION OF HOLE

☒ VERTICAL ☐ INCLINED ________ DEG. FROM VERT.

7. THICKNESS OF OVERBURDEN 35'
8. DEPTH DRILLED INTO ROCK 293'
9. TOTAL DEPTH OF HOLE 500
10. SIZE AND TYPE OF BIT 6" hammer
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Schramm 64
13. TOTAL CORE RECOVERY FOR BORING %
14. TOTAL NUMBER OF CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 10/14/ COMPLETED 10/21
17. ELEVATION TOP OF HOLE 570'
18. NAME OF GEOLOGIST M Wilkening
19. SIGNATURE OF GEOLOGIST M Wilkening

PENET. RATE (ft/hr)	DEPTH (ft)	LITHOLOGY	CLASSIFICATION OF MATERIAL (DESCRIPTION)	WATER LEVEL (DATE)	FLOW-LINE TEMP. IN	FLOW-LINE TEMP. OUT	H₂O (gpm)	TIME / DATE	REMARKS: CASING, CORING POINTS, BOTTOM-HOLE TEMP., WATER SAMPLING AND TEMP. POINTS
	300	X X X	250-341 Basalt cont.						
	310	x x x X							
	320	X x x X							
	330	X x x X							
	340	X x X	341- Basalt, med. grey, vesicular, highly fractured. Plag phenos Rock is notically less dense than previous samples						This zone is where all the air escaped into the fm + foam was used.
	350	X x X							Any contamination in samples (presence of clay etc) is due to washing in from above.
	360	x X X							
	370	X x X							
	380	x X X							
	390	X x X X							
	400								

1861

MULT
56740

DRILLING LOG DIVISION DOGAMI

INSTALLATION Howard Canyon

SHEET 5 OF 5 SHEETS

1. PROJECT Corbett Moffett
2. LOCATION (Coordinates or Station) 1S/4E/1B center
3. DRILLING AGENCY West Coast Drilling
4. HOLE NO. (As shown on drawing title and file number) 1S/4E/1B center
5. NAME OF DRILLER B. Stadeli
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN 35'
8. DEPTH DRILLED INTO ROCK 293'
9. TOTAL DEPTH OF HOLE 500'
10. SIZE AND TYPE OF BIT 6" Hammer
11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
12. MANUFACTURER'S DESIGNATION OF DRILL Schramm 64
13. TOTAL CORE RECOVERY FOR BORING %
14. TOTAL NUMBER OF CORE BOXES
15. ELEVATION GROUND WATER
16. DATE HOLE STARTED 10/16/ COMPLETED 10/21
17. ELEVATION TOP OF HOLE 570'
18. NAME OF GEOLOGIST M Wilkening
19. SIGNATURE OF GEOLOGIST M. Wilkening

PENET. RATE (ft/hr)	DEPTH (ft)	LITHOLOGY	CLASSIFICATION OF MATERIAL (DESCRIPTION)	WATER LEVEL (DATE)	FLOW-LINE TEMP. IN	FLOW-LINE TEMP. OUT	H₂O (gpm)	TIME / DATE	REMARKS: CASING, CORING POINTS, BOTTOM-HOLE TEMP., WATER SAMPLING AND TEMP. POINTS
	400	X X X	341- Basalt cont some vesicles are filled w/ white + bluish zeolites. Trace amts of ~~m~~alteration rinds on some basalt. Many frags have subrounded surfaces.						cont. to lose circ + have sporadic return of cuttings
	410	X							
	420	X X						10/21	Carbonized wood present in cuttings, washing in from above(!)
	430	X X							
	440	X X X							
5-8 min/ft	450	X X X	Basalt remains vesicular, some partially filled. Color remains grey-black. Alteration rinds not apparent.						Note long penetration time due to poor return + constant need for rotating + circulating.
	460	X X X							
	470	X X X X							
2 min/ft	480	X X X							
	490	X X X X							
	500								

MULT
56740

RDS
8SEPT 1987

HYDROGEOLOGIC DATA FOR THE PORTLAND BASIN

WELL NO.- 1S/4E 1BDA DEPTH - 500 ALTITUDE - 570

HYDROGEOLOGIC UNITS	LITHOLOGIC UNTIS	THICKNESS	DEPTH	ALTITUDE
Unconsolidated seds.	Recent alluvium			
	Pleistocene sand and gravel			
	Terrace deposits			
Upper gravels	Springwater Fm.			
	Boring volcs.			
	Cascadian volc. gravels			
	Troutdale (Tt) gravels (TGA)			
Confining layer 1	Tt silt/mudstone			
Upper vitric sandstone aquifer	Tt vitric sand/gravel	90	—	570
Confining layer 2	Tt silt/mudstone	123	90	520
Lower sand and gravel aquifer	Tt sand/gravel/vitric sand			
Bedrock units	Rhododendron Fm.			
	Columbia River basalt	≥ 287	213	307
	Skamania volcanics			
	Goble volcanics			

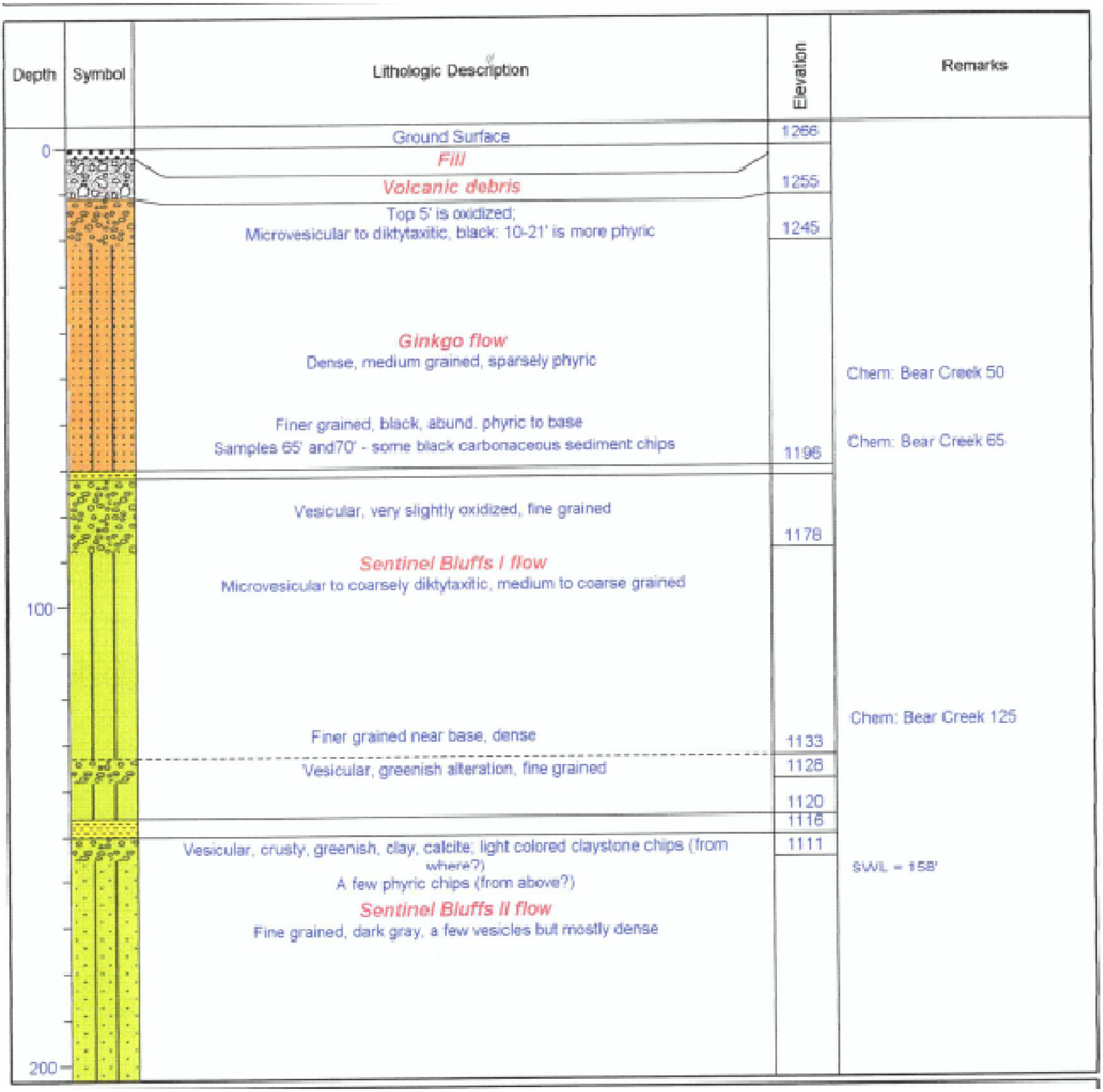
NOTES: DIG ✓
PICKS ✓
D-LITH ✓
ALT ✓
LOG ✓

******* Depths and altitudes are to the top of the indicated units.******

Geologic Log For Site MULT 72559

NWIS Site ID: 452909122050901
OWRD Log ID: MULT 72559
Well location: 01S/06E-17AAD01
Depth drilled, in feet below land surface: 615
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1266.91

Logged by: M. H. Beeson
Date drilled: 12/23/2003



Ground Surface

Fill

Volcanic debris

Top 5' is oxidized;
Microvesicular to diktytaxitic, black: 10-21' is more phyric

Ginkgo flow
Dense, medium grained, sparsely phyric

Finer grained, black, abund. phyric to base
Samples 65' and 70' - some black carbonaceous sediment chips

Chem: Bear Creek 50

Chem: Bear Creek 65

Vesicular, very slightly oxidized, fine grained

Sentinel Bluffs I flow
Microvesicular to coarsely diktytaxitic, medium to coarse grained

Finer grained near base, dense

Chem: Bear Creek 125

Vesicular, greenish alteration, fine grained

Vesicular, crusty, greenish, clay, calcite; light colored claystone chips (from where?)
A few phyric chips (from above?)

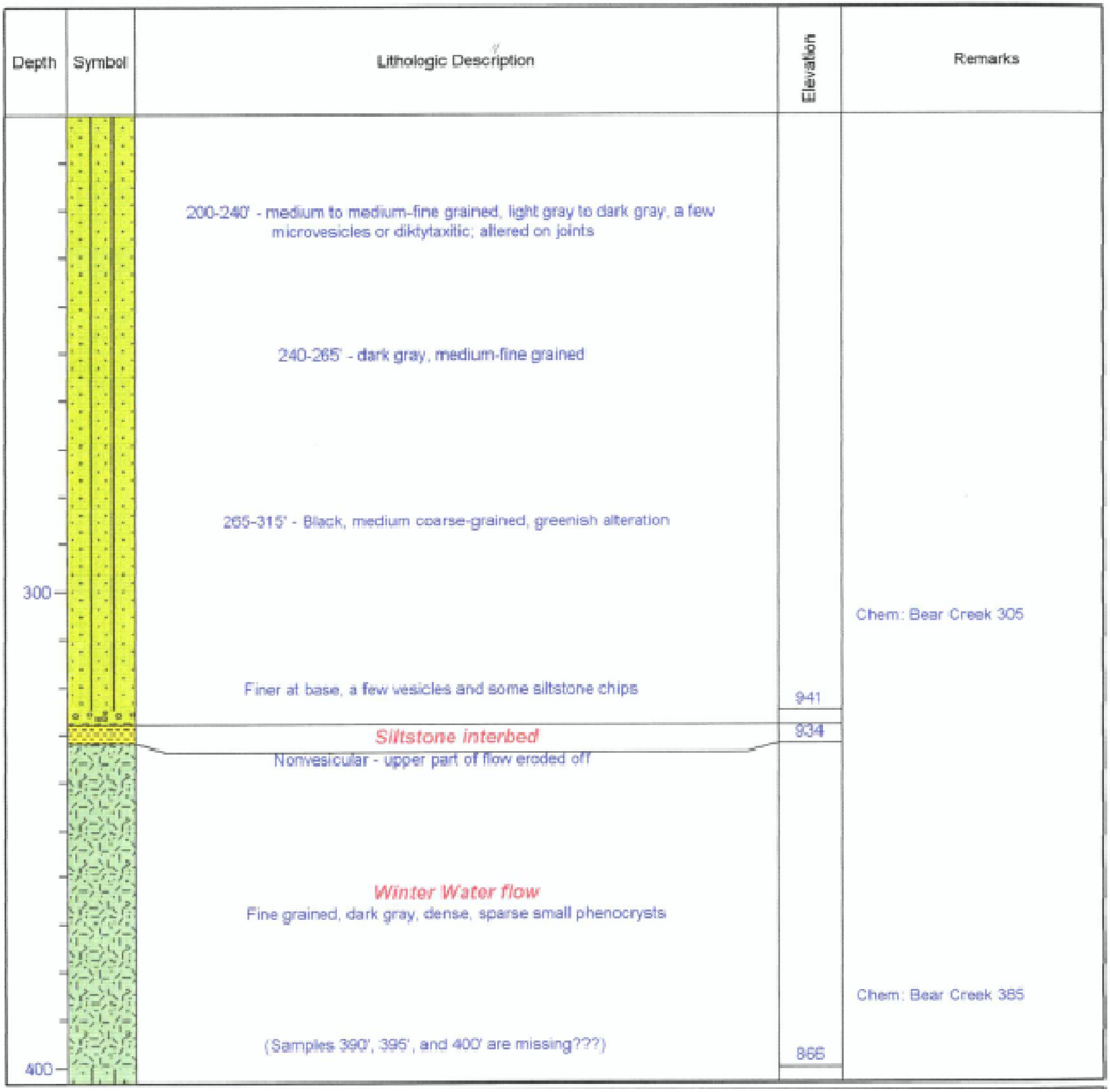
Sentinel Bluffs II flow
Fine grained, dark gray, a few vesicles but mostly dense

SWL = 158'

Geologic Log For Site MULT 72559

NWIS Site ID: 452909122050901
OWRD Log ID: MULT 72559
Well location: 01S/06E-17AAD01
Depth drilled, in feet below land surface: 615
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1266.91

Logged by: M. H. Beeson
Date drilled: 12/23/2003

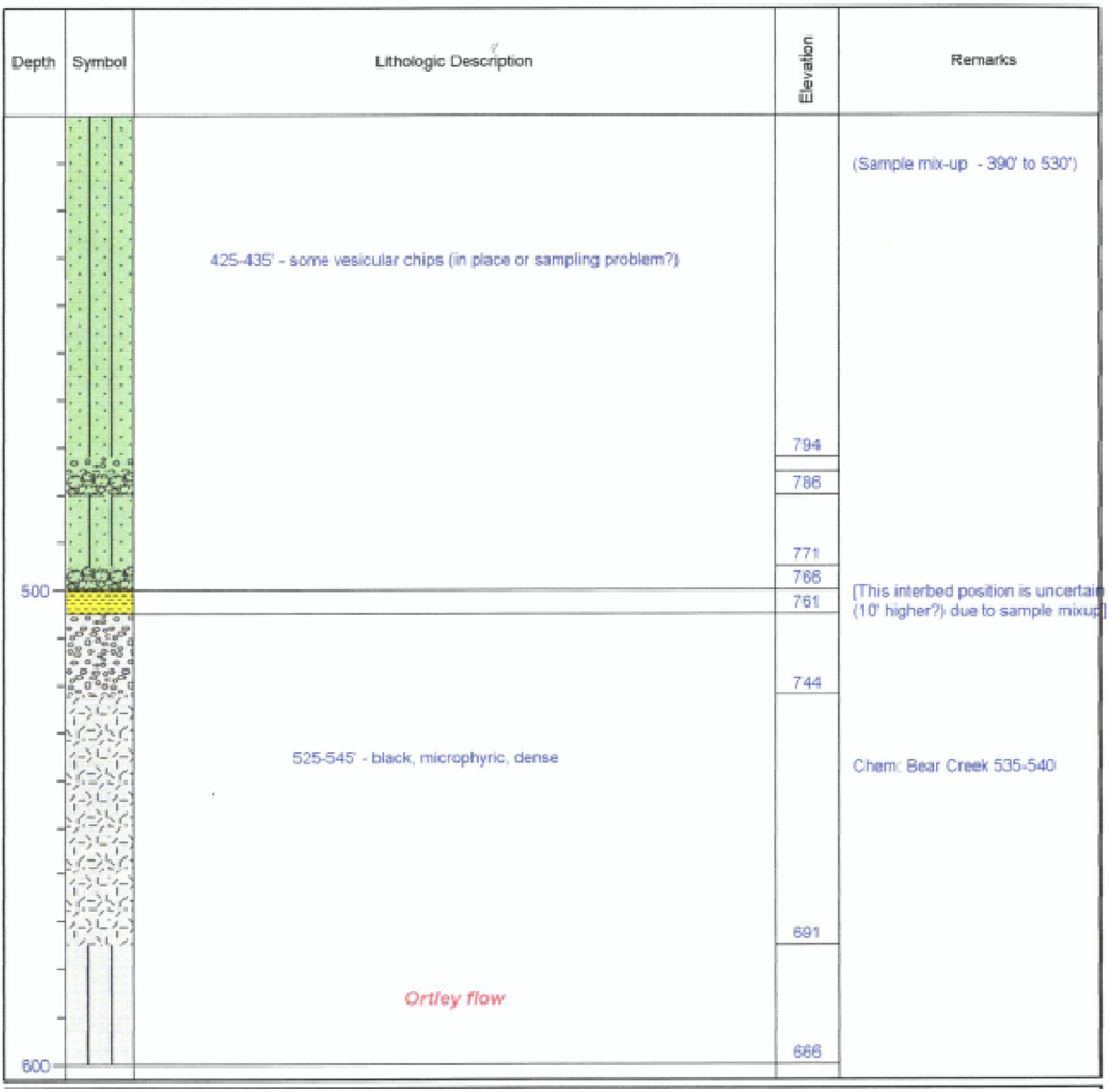


Depth	Symbol	Lithologic Description	Elevation	Remarks
		200-240' - medium to medium-fine grained, light gray to dark gray, a few microvesicles or diktytaxitic; altered on joints		
		240-265' - dark gray, medium-fine grained		
		265-315' - Black, medium coarse-grained, greenish alteration		
300				Chem: Bear Creek 305
		Finer at base, a few vesicles and some siltstone chips	941	
		Siltstone interbed	934	
		Nonvesicular - upper part of flow eroded off		
		Winter Water flow Fine grained, dark gray, dense, sparse small phenocrysts		
				Chem: Bear Creek 385
		(Samples 390', 395', and 400' are missing???)	866	
400				

Geologic Log For Site MULT 72559

NWIS Site ID: 452909122050901
OWRD Log ID: MULT 72559
Well location: 01S/06E-17AAD01
Depth drilled, in feet below land surface: 615
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1266.91

Logged by: M. H. Beeson
Date drilled: 12/23/2003



425-435' - some vesicular chips (in place or sampling problem?)

525-545' - black, microphyric, dense

(Sample mix-up - 390' to 530')

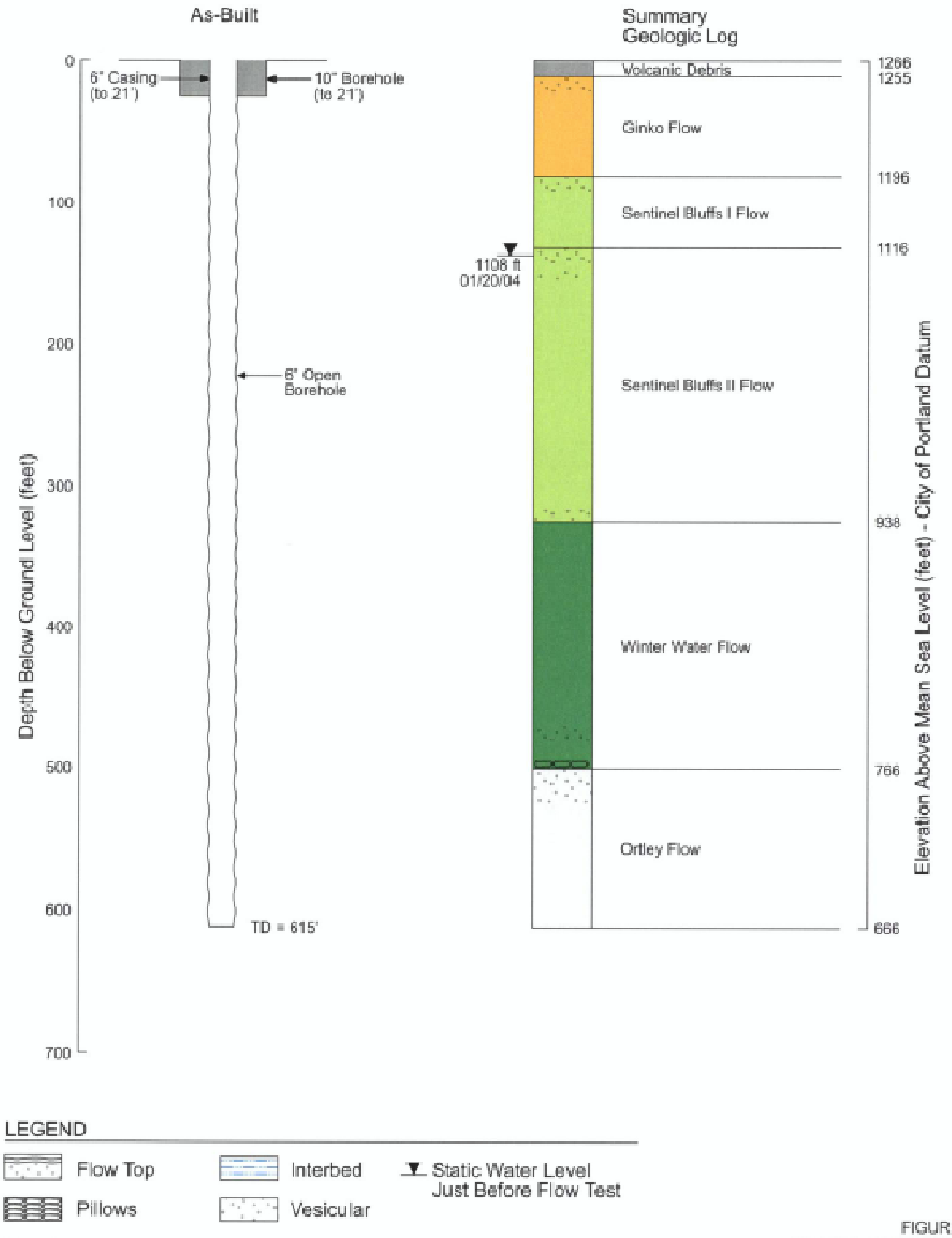
[This interbed position is uncertain (10' higher?) due to sample mixup]

Chem: Bear Creek 535-540

Geologic Log For Site MULT 72559

NWIS Site ID: 452909122050901
OWRD Log ID: MULT 72559
Well location: 01S/06E-17AAD01
Depth drilled, in feet below land surface: 615
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1266.91

Logged by: M. H. Beeson
Date drilled: 12/23/2003



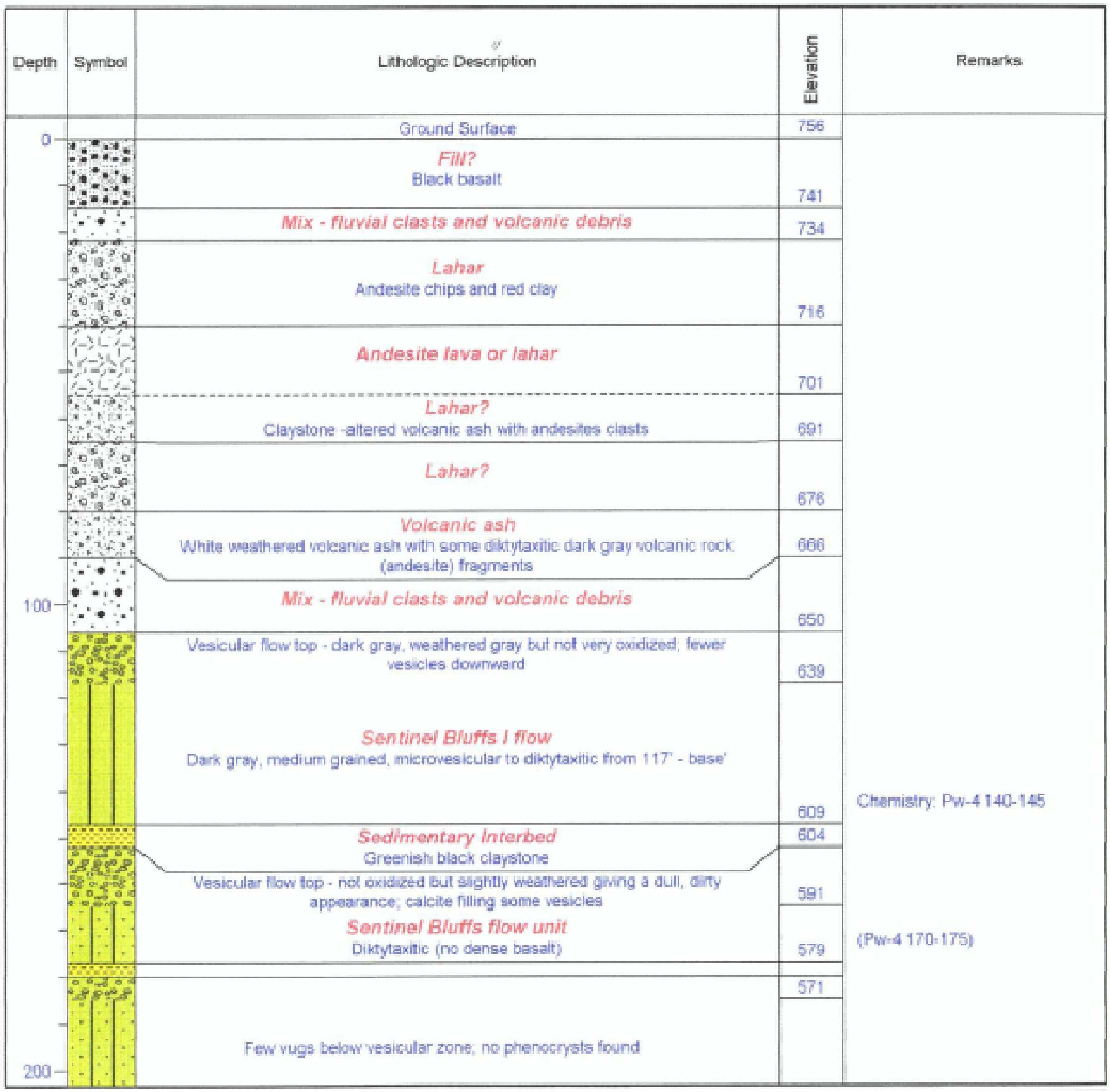
Note: Geologic log is based on logs developed by Dr. Marvin Beeson (See Appendix B)

FIGURE **2-3**
BEAR CREEK WELL
AS-BUILT AND GEOLOGIC LOG
CITY OF PORTLAND/BULL RUN GRW/OR

Geologic Log For Site MULT 72560

NWIS Site ID: 452656122085701
OWRD Log ID: MULT 72560
Well location: 01S/05E-26DDB01
Depth drilled, in feet below land surface: 690
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 756.86

Logged by: M. H. Beeson
Date drilled: 12/13/2003

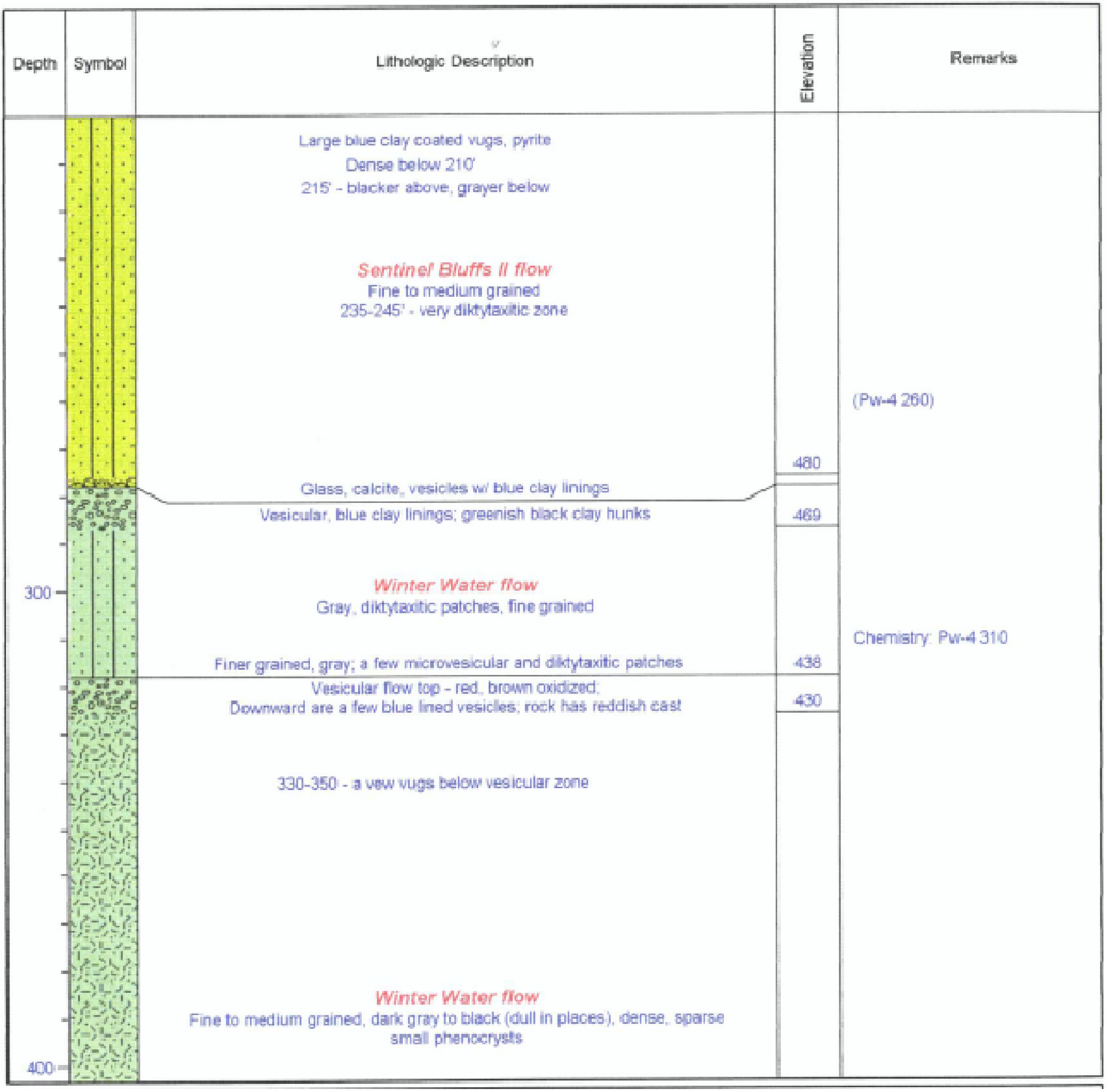


Depth	Symbol	Lithologic Description	Elevation	Remarks
		Ground Surface	756	
0		Fill? Black basalt	741	
		Mix - fluvial clasts and volcanic debris	734	
		Lahar Andesite chips and red clay	716	
		Andesite lava or lahar	701	
		Lahar? Claystone -altered volcanic ash with andesites clasts	691	
		Lahar?	676	
		Volcanic ash White weathered volcanic ash with some diktytaxitic dark gray volcanic rock (andesite) fragments	666	
100		Mix - fluvial clasts and volcanic debris	650	
		Vesicular flow top - dark gray, weathered gray but not very oxidized; fewer vesicles downward	639	
		Sentinel Bluffs I flow Dark gray, medium grained, microvesicular to diktytaxitic from 117' - base'	609	Chemistry: Pw-4 140-145
		Sedimentary Interbed Greenish black claystone	604	
		Vesicular flow top - not oxidized but slightly weathered giving a dull, dirty appearance; calcite filling some vesicles	591	
		Sentinel Bluffs flow unit Diktytaxitic (no dense basalt)	579	(Pw-4 170-175)
			571	
200		Few vugs below vesicular zone; no phenocrysts found		

Geologic Log For Site MULT 72560

NWIS Site ID: 452656122085701
OWRD Log ID: MULT 72560
Well location: 01S/05E-26DDB01
Depth drilled, in feet below land surface: 690
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 756.86

Logged by: M. H. Beeson
Date drilled: 12/13/2003



Large blue clay coated vugs, pyrite
Dense below 210'
215' - blacker above, grayer below

Sentinel Bluffs II flow
Fine to medium grained
235-245' - very diktytaxitic zone

(Pw-4 260)

Glass, calcite, vesicles w/ blue clay linings
Vesicular, blue clay linings; greenish black clay hunks

Winter Water flow
Gray, diktytaxitic patches, fine grained

Chemistry: Pw-4 310

Finer grained, gray; a few microvesicular and diktytaxitic patches

Vesicular flow top - red, brown oxidized;
Downward are a few blue lined vesicles; rock has reddish cast

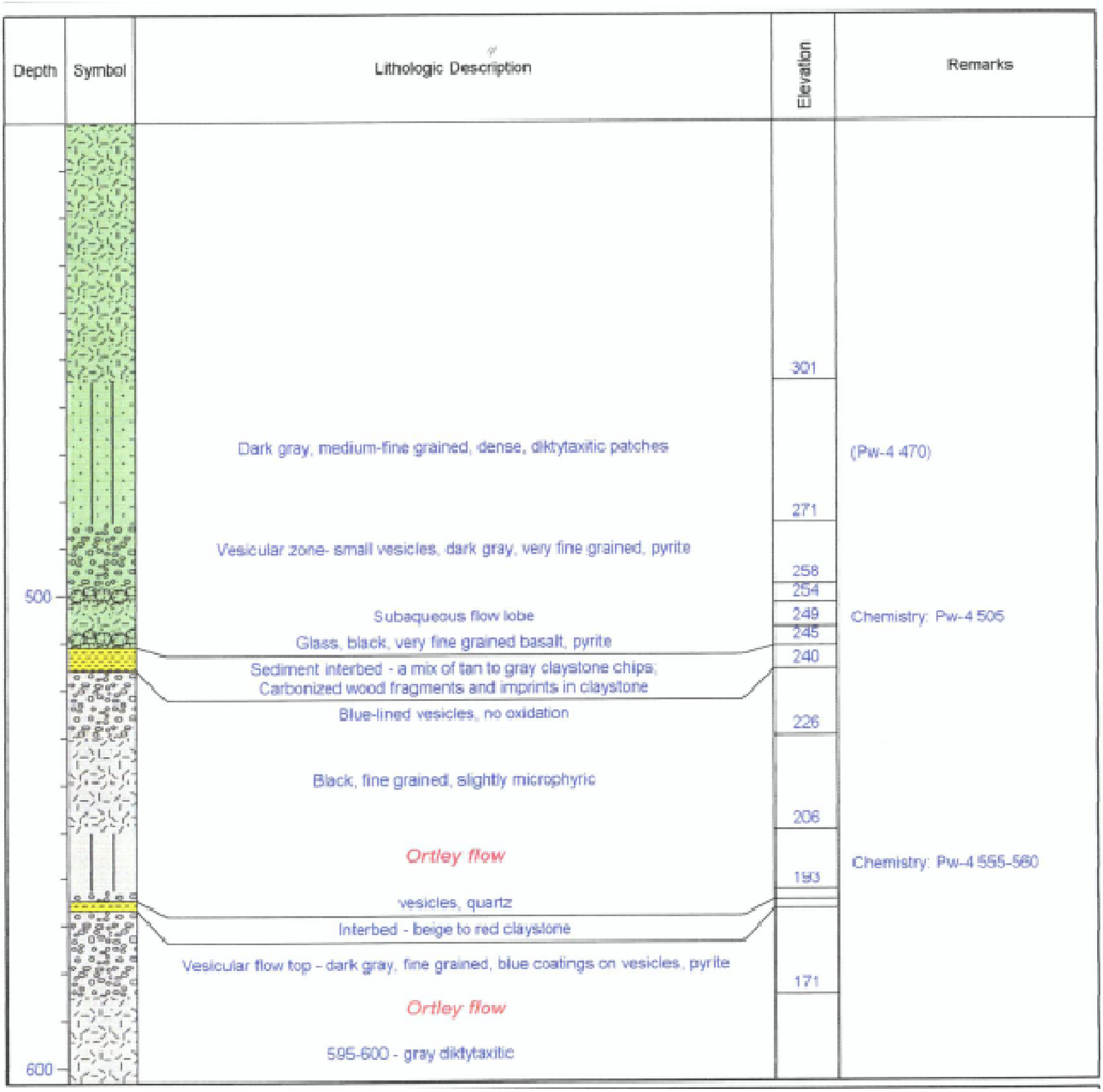
330-350 - a vew vugs below vesicular zone

Winter Water flow
Fine to medium grained, dark gray to black (dull in places), dense, sparse small phenocrysts

Geologic Log For Site MULT 72560

NWIS Site ID: 452656122085701
OWRD Log ID: MULT 72560
Well location: 01S/05E-26DDB01
Depth drilled, in feet below land surface: 690
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 756.86

Logged by: M. H. Beeson
Date drilled: 12/13/2003

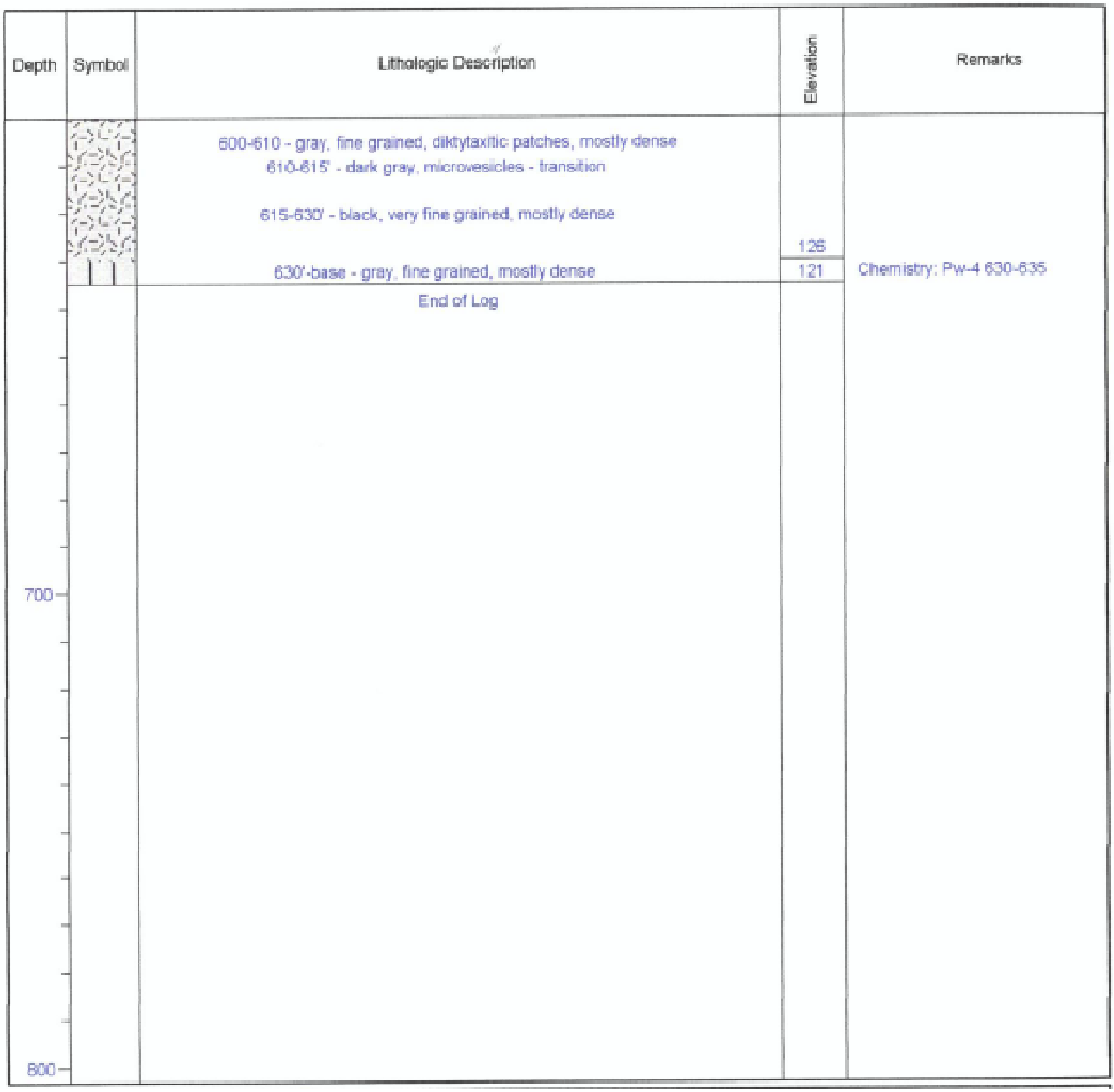


Lithologic Description	Elevation	Remarks
	301	
Dark gray, medium-fine grained, dense, diktytaxitic patches		(Pw-4 470)
	271	
Vesicular zone- small vesicles, dark gray, very fine grained, pyrite	258	
	254	
Subaqueous flow lobe	249	Chemistry: Pw-4 506
Glass, black, very fine grained basalt, pyrite	245	
	240	
Sediment interbed - a mix of tan to gray claystone chips; Carbonized wood fragments and imprints in claystone		
Blue-lined vesicles, no oxidation	226	
Black, fine grained, slightly microphyric	206	
Ortley flow		Chemistry: Pw-4 555-560
	193	
vesicles, quartz		
Interbed - beige to red claystone		
Vesicular flow top - dark gray, fine grained, blue coatings on vesicles, pyrite	171	
Ortley flow		
595-600 - gray diktytaxitic		

Geologic Log For Site MULT 72560

NWIS Site ID: 452656122085701
OWRD Log ID: MULT 72560
Well location: 01S/05E-26DDB01
Depth drilled, in feet below land surface: 690
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 756.86

Logged by: M. H. Beeson
Date drilled: 12/13/2003

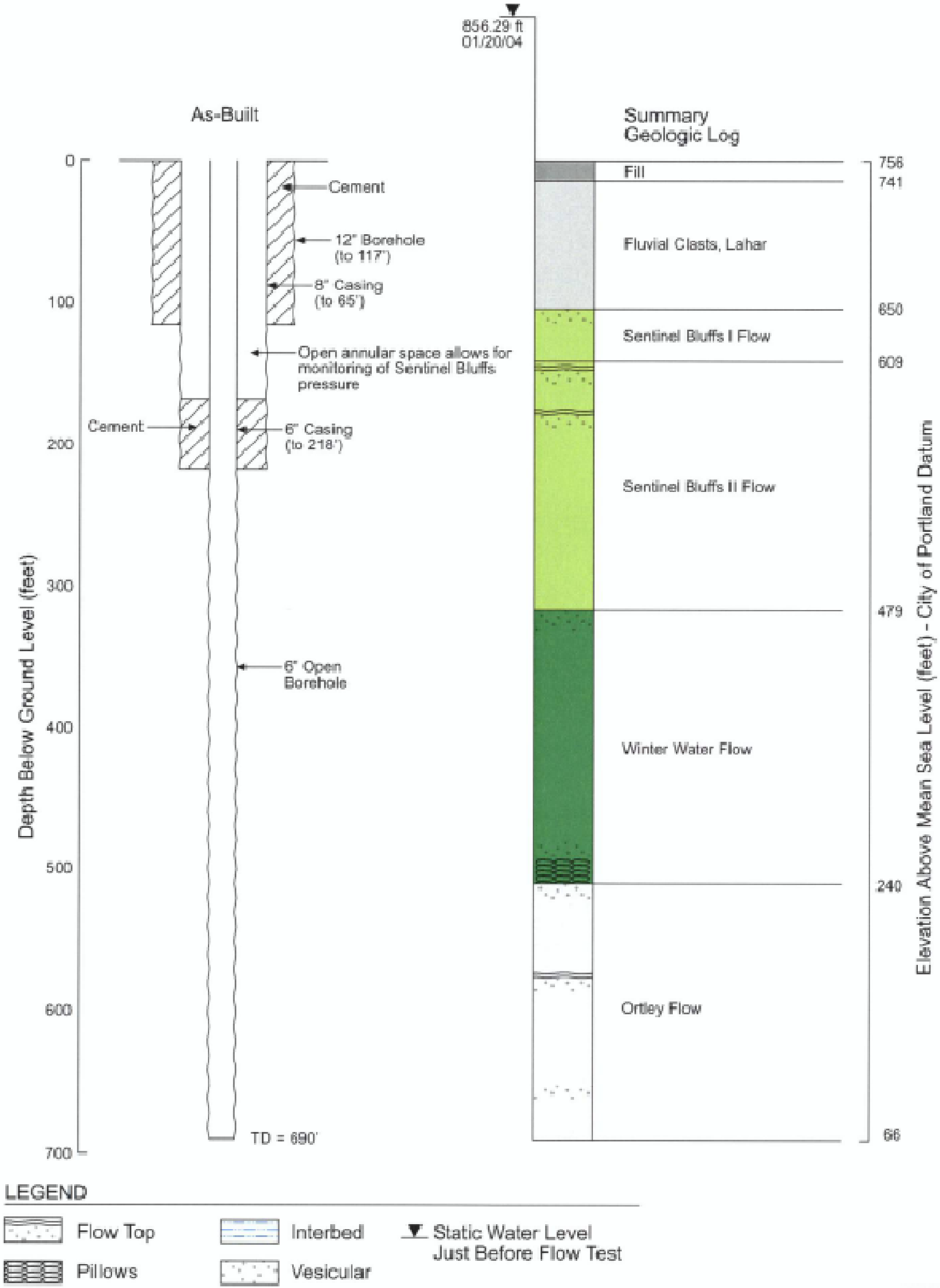


Depth	Symbol	Lithologic Description	Elevation	Remarks
		600-610 - gray, fine grained, diktytaxitic patches, mostly dense		
		610-615' - dark gray, microvesicles - transition		
		615-630' - black, very fine grained, mostly dense	126	
		630'-base - gray, fine grained, mostly dense	121	Chemistry: Pw-4 630-635
		End of Log		
700				
800				

Geologic Log For Site MULT 72560

NWIS Site ID: 452656122085701
OWRD Log ID: MULT 72560
Well location: 01S/05E-26DDB01
Depth drilled, in feet below land surface: 690
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 756.86

Logged by: M. H. Beeson
Date drilled: 12/13/2003



Note: Geologic log is based on logs developed by Dr. Marvin Beeson (See Appendix B)

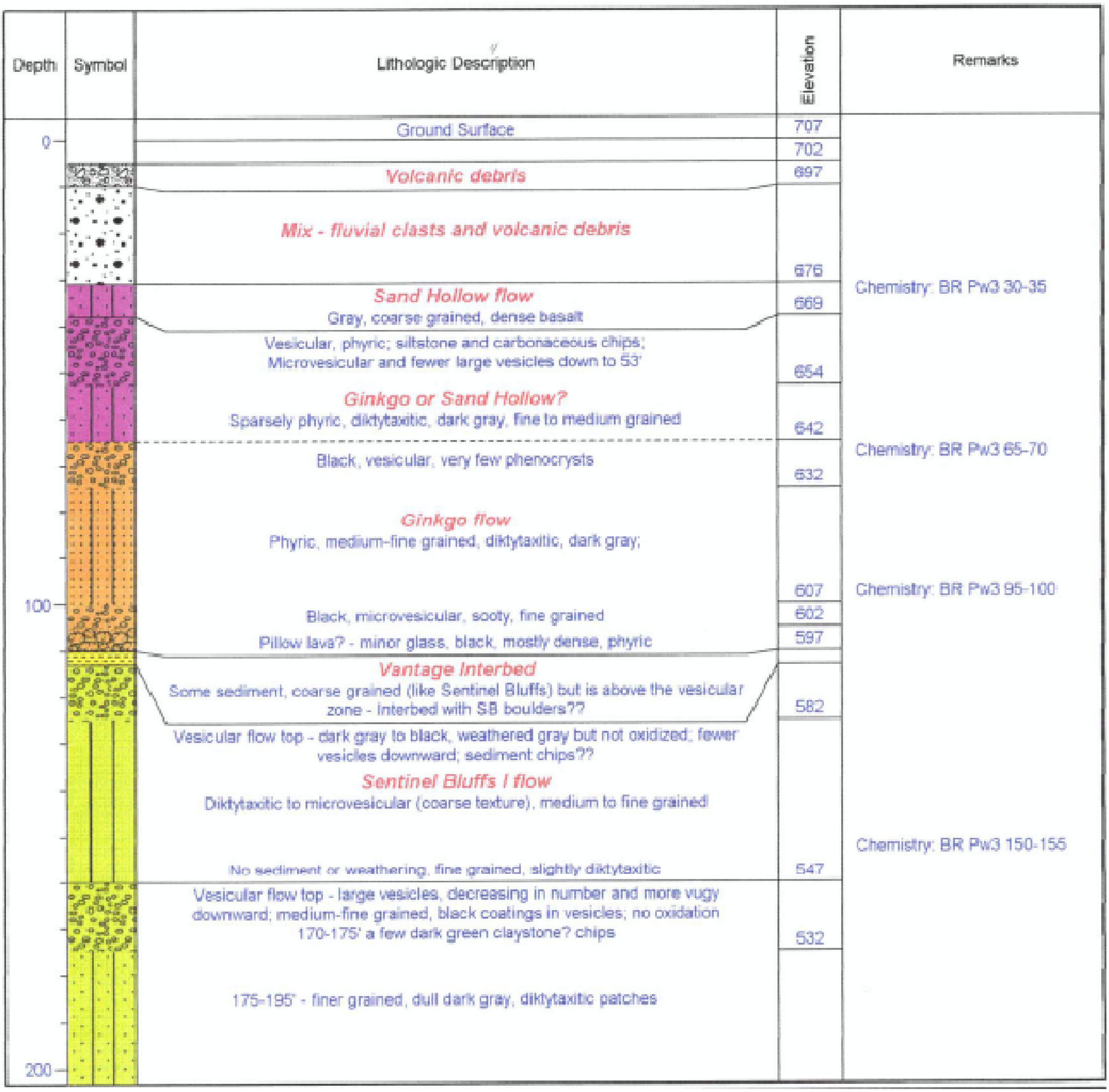
Well was deepened from 635ft to 690ft in May 2004. The lower portion of the hole is believed to be in the Ortley flow, but it has not yet been confirmed.

FIGURE **2-2**
PILOT WELL 4
AS-BUILT AND GEOLOGIC LOG
CITY OF PORTLAND/BULL RUN GRW/OR

Geologic Log For Site MULT 72561

NWIS Site ID: 452649122092501
OWRD Log ID: MULT 72561
Well location: 01S/05E-26CDD01
Depth drilled, in feet below land surface: 675
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 710.62

Logged by: M. H. Beeson
Date drilled: 12/18/2003

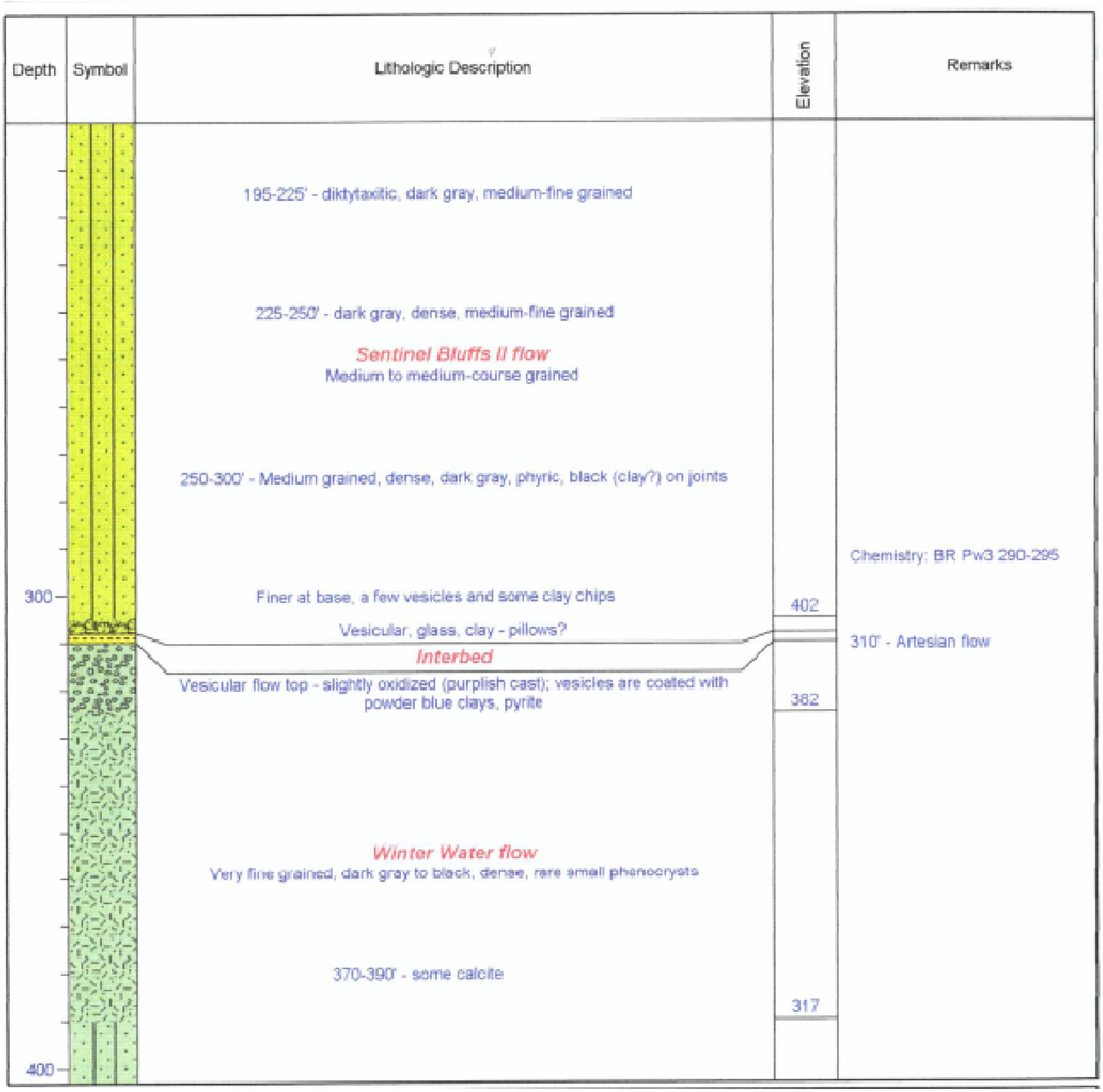


Depth	Symbol	Lithologic Description	Elevation	Remarks
0		Ground Surface	707	
			702	
		Volcanic debris	697	
		Mix - fluvial clasts and volcanic debris	676	
		Sand Hollow flow Gray, coarse grained, dense basalt	669	Chemistry: BR Pw3 30-35
		Vesicular, phyric; siltstone and carbonaceous chips; Microvesicular and fewer large vesicles down to 53'	654	
		Ginkgo or Sand Hollow? Sparsely phyric, diktytaxitic, dark gray, fine to medium grained	642	
		Black, vesicular, very few phenocrysts	632	Chemistry: BR Pw3 65-70
		Ginkgo flow Phyric, medium-fine grained, diktytaxitic, dark gray;	607	Chemistry: BR Pw3 95-100
100		Black, microvesicular, sooty, fine grained	602	
		Pillow lava? - minor glass, black, mostly dense, phyric	597	
		Vantage Interbed Some sediment, coarse grained (like Sentinel Bluffs) but is above the vesicular zone - Interbed with SB boulders??	582	
		Vesicular flow top - dark gray to black, weathered gray but not oxidized; fewer vesicles downward; sediment chips?? *Sentinel Bluffs I flow* Diktytaxitic to microvesicular (coarse texture), medium to fine grained		Chemistry: BR Pw3 150-155
		No sediment or weathering, fine grained, slightly diktytaxitic	547	
		Vesicular flow top - large vesicles, decreasing in number and more vugy downward; medium-fine grained, black coatings in vesicles; no oxidation 170-175' a few dark green claystone? chips	532	
		175-195' - finer grained, dull dark gray, diktytaxitic patches		
200				

Geologic Log For Site MULT 72561

NWIS Site ID: 452649122092501
OWRD Log ID: MULT 72561
Well location: 01S/05E-26CDD01
Depth drilled, in feet below land surface: 675
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 710.62

Logged by: M. H. Beeson
Date drilled: 12/18/2003



195-225' - diktytaxitic, dark gray, medium-fine grained

225-250' - dark gray, dense, medium-fine grained

Sentinel Bluffs II flow
Medium to medium-course grained

250-300' - Medium grained, dense, dark gray, phyric, black (clay?) on joints

Finer at base, a few vesicles and some clay chips

Vesicular, glass, clay - pillows?

Interbed

Vesicular flow top - slightly oxidized (purplish cast); vesicles are coated with powder blue clays, pyrite

Winter Water flow
Very fine grained, dark gray to black, dense, rare small phenocrysts

370-390' - some calcite

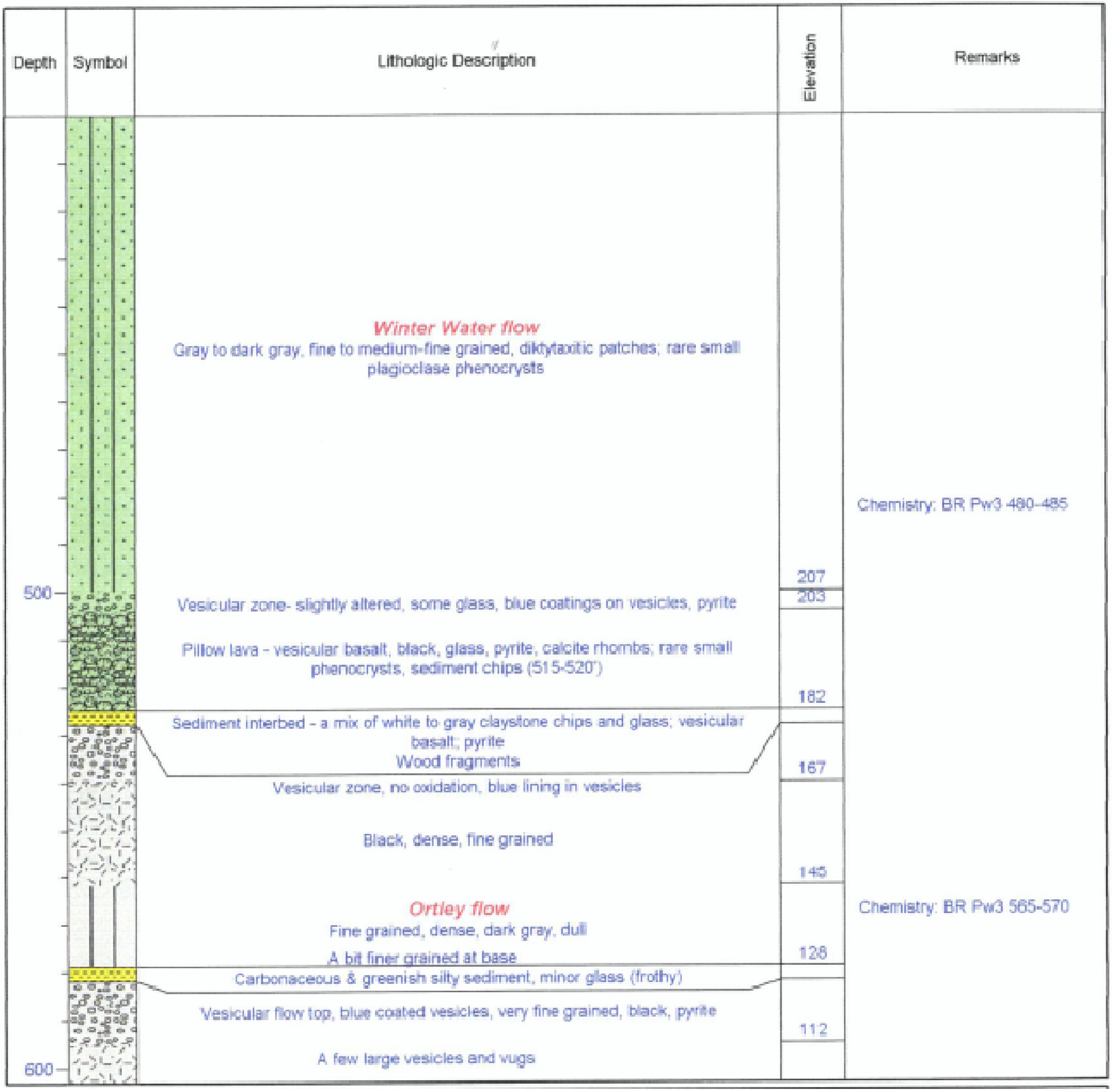
Chemistry: BR Pw3 290-295

310' - Artesian flow

Geologic Log For Site MULT 72561

NWIS Site ID: 452649122092501
OWRD Log ID: MULT 72561
Well location: 01S/05E-26CDD01
Depth drilled, in feet below land surface: 675
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 710.62

Logged by: M. H. Beeson
Date drilled: 12/18/2003



Winter Water flow
Gray to dark gray, fine to medium-fine grained, diktytaxitic patches; rare small plagioclase phenocrysts

Chemistry: BR Pw3 480-485

Vesicular zone- slightly altered, some glass, blue coatings on vesicles, pyrite

Pillow lava - vesicular basalt, black, glass, pyrite, calcite rhombs; rare small phenocrysts, sediment chips (515-520')

Sediment interbed - a mix of white to gray claystone chips and glass; vesicular basalt; pyrite
Wood fragments

Vesicular zone, no oxidation, blue lining in vesicles

Black, dense, fine grained

Ortley flow
Fine grained, dense, dark gray, dull
A bit finer grained at base

Chemistry: BR Pw3 565-570

Carbonaceous & greenish silty sediment, minor glass (frothy)

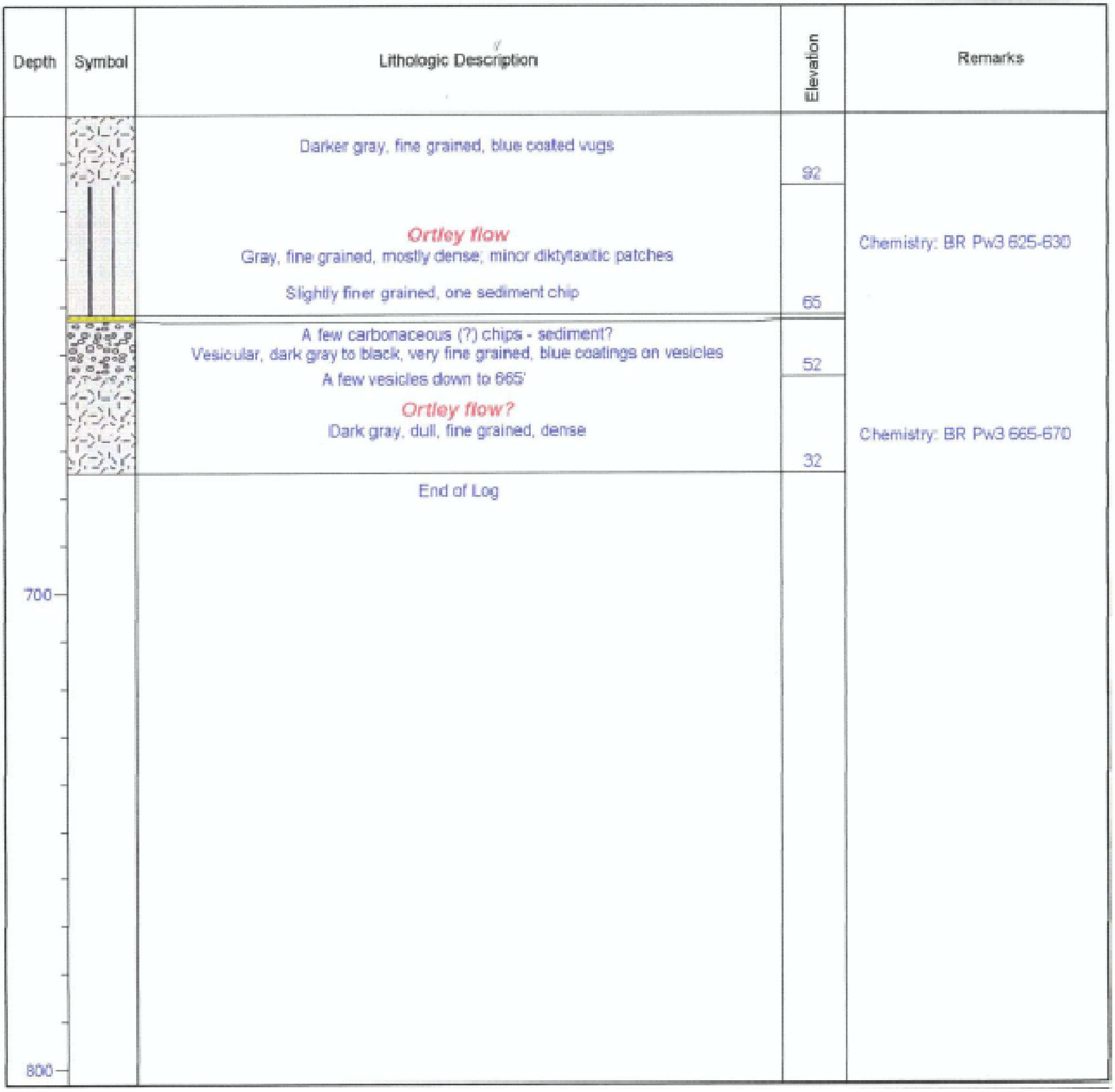
Vesicular flow top, blue coated vesicles, very fine grained, black, pyrite

A few large vesicles and vugs

Geologic Log For Site MULT 72561

NWIS Site ID: 452649122092501
OWRD Log ID: MULT 72561
Well location: 01S/05E-26CDD01
Depth drilled, in feet below land surface: 675
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 710.62

Logged by: M. H. Beeson
Date drilled: 12/18/2003



Depth	Symbol	Lithologic Description	Elevation	Remarks
		Darker gray, fine grained, blue coated vugs	92	
		Ortley flow Gray, fine grained, mostly dense; minor diktytaxitic patches Slightly finer grained, one sediment chip	65	Chemistry: BR Pw3 625-630
		A few carbonaceous (?) chips - sediment? Vesicular, dark gray to black, very fine grained, blue coatings on vesicles	52	
		A few vesicles down to 665' Ortley flow? Dark gray, dull, fine grained, dense	32	Chemistry: BR Pw3 665-670
		End of Log		
700				
800				

Geologic Log For Site MULT 72561

NWIS Site ID: 452649122092501
OWRD Log ID: MULT 72561
Well location: 01S/05E-26CDD01
Depth drilled, in feet below land surface: 675
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 710.62

Logged by: M. H. Beeson
Date drilled: 12/18/2003

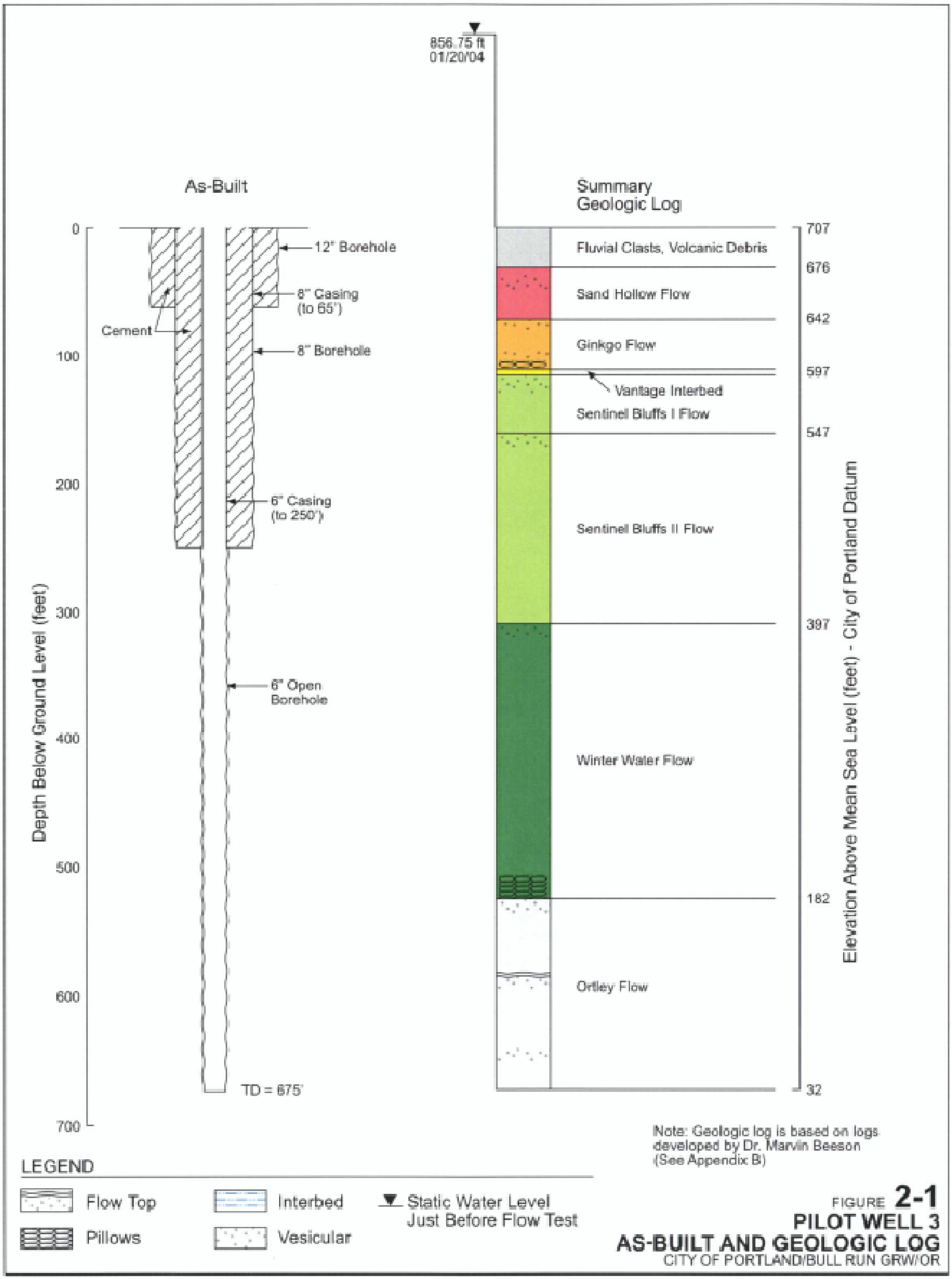
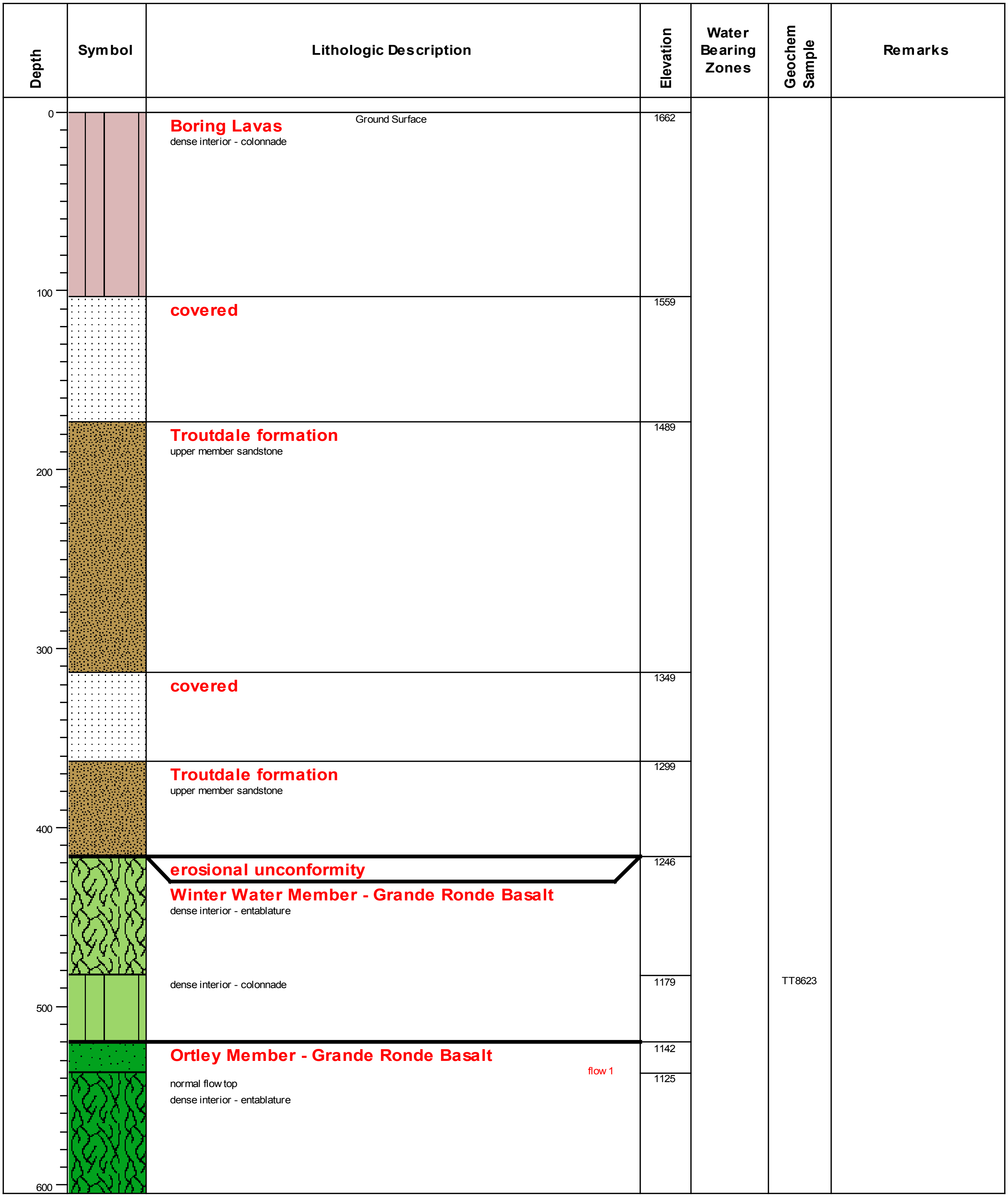


FIGURE **2-1**
PILOT WELL 3
AS-BUILT AND GEOLOGIC LOG
CITY OF PORTLAND/BULL RUN GRW/OR

Geologic Log For Site MULT FALLS

NWIS Site ID: 453418122064901
OWRD Log ID: MULT FALLS
Well location: 01N/06E-18ACB
Depth drilled, in feet below land surface: 1662
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1662

Logged by: T. L. Tolan

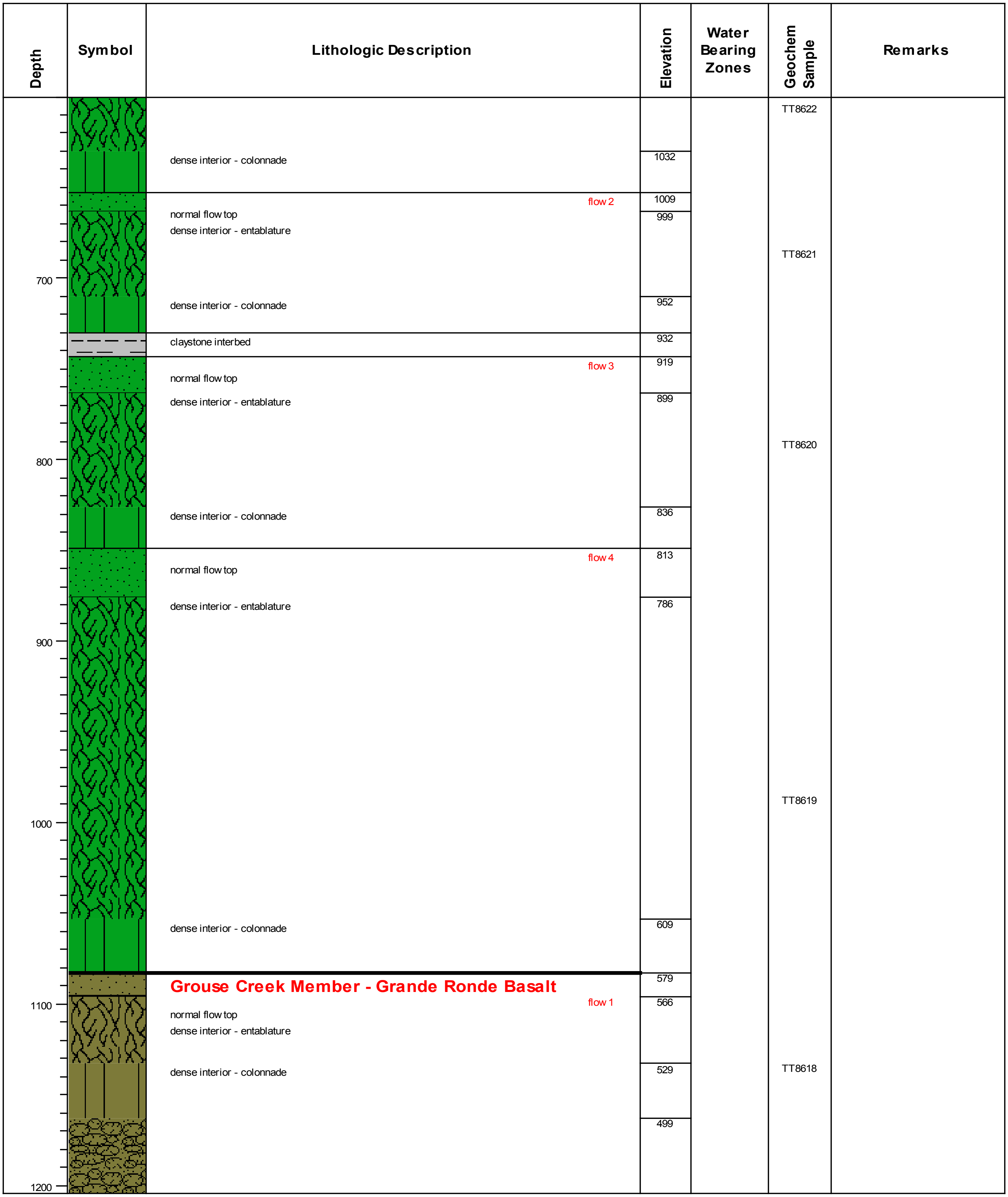


Lithologic Description	Elevation	Water Bearing Zones	Geochem Sample	Remarks
Ground Surface **Boring Lavas** dense interior - colonnade	1662			
covered	1559			
Troutdale formation upper member sandstone	1489			
covered	1349			
Troutdale formation upper member sandstone	1299			
erosional unconformity **Winter Water Member - Grande Ronde Basalt** dense interior - entablature	1246			
dense interior - colonnade	1179		TT8623	
Ortley Member - Grande Ronde Basalt flow 1	1142			
normal flow top dense interior - entablature	1125			

Geologic Log For Site MULT FALLS

NWIS Site ID: 453418122064901
OWRD Log ID: MULT FALLS
Well location: 01N/06E-18ACB
Depth drilled, in feet below land surface: 1662
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1662

Logged by: T. L. Tolan

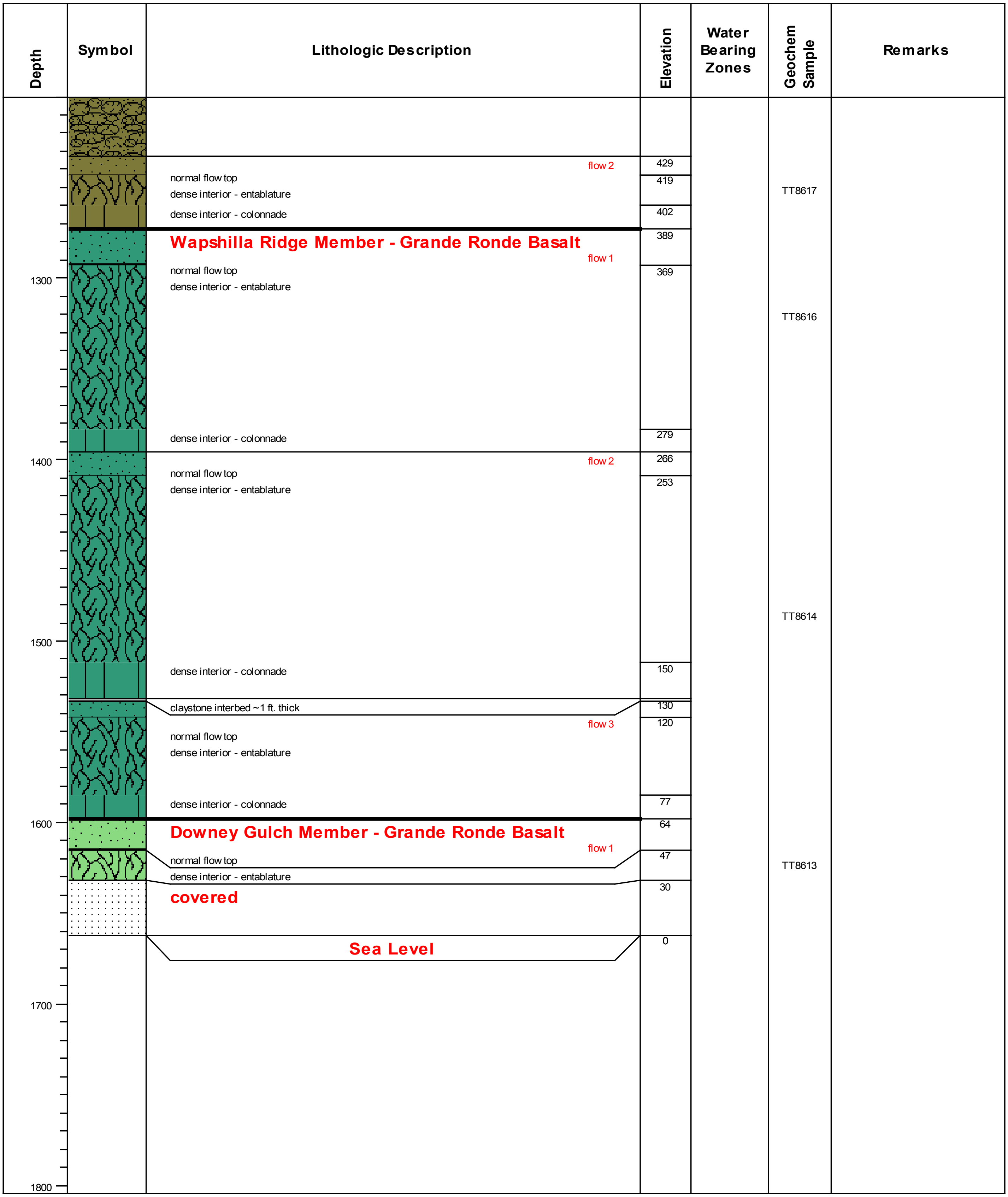


Lithologic Description	Elevation	Water Bearing Zones	Geochem Sample	Remarks
			TT8622	
dense interior - colonnade	1032			
flow 2	1009			
normal flow top				
dense interior - entablature	999			
			TT8621	
dense interior - colonnade	952			
claystone interbed	932			
flow 3	919			
normal flow top				
dense interior - entablature	899			
			TT8620	
dense interior - colonnade	836			
flow 4	813			
normal flow top				
dense interior - entablature	786			
			TT8619	
dense interior - colonnade	609			
Grouse Creek Member - Grande Ronde Basalt	579			
flow 1	566			
normal flow top				
dense interior - entablature				
dense interior - colonnade	529		TT8618	
	499			

Geologic Log For Site MULT FALLS

NWIS Site ID: 453418122064901
OWRD Log ID: MULT FALLS
Well location: 01N/06E-18ACB
Depth drilled, in feet below land surface: 1662
Land surface altitude, in feet above Nation Geodetic Vertical Datum of 1929: 1662

Logged by: T. L. Tolan



Depth	Symbol	Lithologic Description	Elevation	Water Bearing Zones	Geochem Sample	Remarks
		flow 2	429			
		normal flow top	419			
		dense interior - entablature			TT8617	
		dense interior - colonnade	402			
		Wapshilla Ridge Member - Grande Ronde Basalt	389			
		flow 1				
1300		normal flow top	369			
		dense interior - entablature				
					TT8616	
		dense interior - colonnade	279			
1400		flow 2	266			
		normal flow top	253			
		dense interior - entablature				
					TT8614	
1500						
		dense interior - colonnade	150			
		claystone interbed ~1 ft. thick	130			
		flow 3	120			
		normal flow top				
		dense interior - entablature				
		dense interior - colonnade	77			
1600		**Downey Gulch Member - Grande Ronde Basalt**	64			
		flow 1				
		normal flow top	47		TT8613	
		dense interior - entablature				
		covered	30			
		Sea Level	0			
1700						
1800						

APPENDIX B DRILLER COST ESTIMATES

HOLT SERVICES INC

10621 Todd Road East
Edgewood, WA 98372
253 604-4878

ESTIMATE 7/26/2018

Client: Aspect Consulting
Contact: Christopher Augustine
Email: caugustine@aspectconsulting.com
Tel: 971-865-5895

Project: 1300 foot 16 inch PW well

Drill Type: **Dual/Mud Rotary/ Air/ RC**

Item	Description	Unit	Quantity	Price	Total
1	Mobilization of Drilling Equipment	LS	1	$ 32,000.00	$ 32,000.00
2	Set up Site Rig up and Rig down	LS	1	$ 7,500.00	$ 7,500.00
3	Drill install and Remove 20" Temporary Conductor Casing	LF	20	$ 290.00	$ 5,800.00
4	Drill 19-inch Open Borehole with down hole hammer to 200 Feet	LF	180	$ 285.00	$ 51,300.00
5	Switch to Mud Rotary and drill 19" hole to 800 feet	LF	600	$ 245.00	$ 147,000.00
6	Furnish and Install 16-inch Production Casing	LF	800	$ 104.00	$ 83,200.00
7	Furnish and Install Grout Seal WOC (Min 24hrs)	LF	800	$ 58.00	$ 46,400.00
8	Drill 15-inch Air/Reverse Circulation Open Borehole	LF	500	$ 240.00	$ 120,000.00
9	Initial Well Development (performed with R-C bit during final retrieval)	HRS	4	$ 650.00	$ 2,600.00
10	Final Well Development (Performed with Test Pump or Mechanical Swabbing)	HRS	6	$ 385.00	$ 2,310.00
11	Mobilization/Demob for Pump Installation	LS	1	$ 9,500.00	$ 9,500.00
12	Equipment/Generator Rental	LS	1	$ 3,800.00	$ 3,800.00
13	Install and Remove Test Pump	LS	1	$ 18,000.00	$ 18,000.00
14	Operate Test Pump	HRS	80	$ 315.00	$ 25,200.00
15	Perform Well Disinfection, Alignment Test and Cap Well	LS	1	$ 5,200.00	$ 5,200.00
16	Demobilization of Drilling Equipment	LS	1	$ 25,000.00	$ 25,000.00
	Subtotal				**$ 584,810.00**
	Sales Tax			0.0%	$ -

Rig Rates for Additional Work:

1	Rig Operating Rate for Additional Work (Non Drilling)	Per Hour	$650.00
2	Rig and Crew Standby Delays	Per Hour	$550.00

Exclusions:

1. Access road to drilling location, drilling pad construction, site prep and restoration.
2. Transportation or disposal of cuttings and drilling fluids off site.
3. Delays out of the control of the driller
4. Repair of damage to unmarked utilities
5. Unspecified obstruction drilling (i.e.: footings, foundations etc.)
6. Drilling water supply
7. Union or prevailing/Davis Bacon wages
8. Performance and payment bonds
9. Re-drilling of bore holes due to caving or collapsed formations
10. Any additional work not explicitly included in bid proposal
11. Traffic control measures
12. Noise Control (i.e.: sound panels or blankets)
13. Permits or licenses (i.e.: traffic control, encroachment, discharge, erosion control, etc.)
14. Sales tax or use taxes. (All applicable taxes will be added at time of invoicing)

Assumptions:

1. Work has been bid based upon the information provided to Holt with the following exclusions listed above. Work will be billed
2. Level drill pad 100' X 60' with access, adequate for 2WD rubber tired equipment accompanied by nearby staging area for semi
3. Drilling spoils and all fluids generated will be discharged to sumps or containers provided by others
4. An adequate water supply (2" line) will be provided at or near the drill site by the client at no expense to Holt.
5. Holt Can provide hauling services for transporting water to the drill site at 85.00/hr
6. All shift delays required for items such as insufficient access, water level measurements or client requested safety training/pauses,
7. Any re-drilling, hole conditioning or extra tripping of boreholes required will be charged at the provided rig hourly rate, plus
8. Annular material quantities that exceed 120% of theoretical annulus volumes will be billed at provided unit rates or cost plus 15%,
9. This proposal is subject to rig and crew availability. Neither party shall be bound by the terms of this proposal until a separate

Thank you for requesting this proposal from Holt Services. We look forward to the opportunity to work with you on this project.

Sincerely,

Robert Stadeli
Holt Services, Inc.
MBL: 503-572-9396
rstadeli@holtservicesinc.com

HOLT SERVICES INC
10621 Todd Road East
Edgewood, WA 98372
253 604-4878

ESTIMATE 7/26/2018

Client: Aspect Consulting
Contact: Christopher Augustine
Email: caugustine@aspectconsulting.com
Tel: 971-865-5895

Project: 1300 foot 10 inch test well

Drill Type: **Dual/Mud Rotary/ Air/ RC**

Item	Description	Unit	Quantity	Price	Total
1	Mobilization of Drilling Equipment	LS	1	$ 22,000.00	$ 22,000.00
2	Set up Site Rig up and Rig down	LS	1	$ 4,500.00	$ 4,500.00
3	Drill install and Remove 16" Temporary Conductor Casing	LF	20	$ 210.00	$ 4,200.00
4	Drill 15-inch Open Borehole with down hole hammer to 200 Feet	LF	180	$ 175.00	$ 31,500.00
5	Switch to Mud Rotary and drill 14-3/4 hole to 800 feet	LF	600	$ 185.00	$ 111,000.00
6	Furnish and Install 10-inch Production Casing	LF	800	$ 62.00	$ 49,600.00
7	Furnish and Install Grout Seal WOC (Min 24hrs)	LF	800	$ 48.00	$ 38,400.00
8	Drill 10-inch Air/Reverse Circulation Open Borehole	LF	500	$ 145.00	$ 72,500.00
9	Initial Well Development (performed with R-C bit durinq final retrieval)	HRS	4	$ 650.00	$ 2,600.00
10	Final Well Development (Performed with Test Pump or Mechanical Swabbinq)	HRS	6	$ 360.00	$ 2,160.00
11	Mobilization/Demob for Pump Installation	LS	1	$ 7,500.00	$ 7,500.00
12	Equipment/Generator Rental	LS	1	$ 2,400.00	$ 2,400.00
13	Install and Remove Test Pump	LS	1	$ 16,000.00	$ 16,000.00
14	Operate Test Pump	HRS	80	$ 295.00	$ 23,600.00
15	Perform Well Disinfection, Alignment Test and Cap Well	LS	1	$ 4,000.00	$ 4,000.00
16	Demobilization of Drilling Equipment	LS	1	$ 12,000.00	$ 12,000.00
	Subtotal				**$ 403,960.00**
	Sales Tax			0.0%	$ -

Rig Rates for Additional Work:

1	Rig Operating Rate for Additional Work (Non Drilling)	Per Hour	$650.00
2	Rig and Crew Standby Delays	Per Hour	$550.00

Exclusions:

1 Access road to drilling location, drilling pad construction, site prep and restoration.
2 Transportation or disposal of cuttings and drilling fluids off site.
3 Delays out of the control of the driller
4 Repair of damage to unmarked utilities
5 Unspecified obstruction drilling (i.e.: footings, foundations etc.)
6 Drilling water supply
7 Union or prevailing/Davis Bacon wages
8 Performance and payment bonds
9 Re-drilling of bore holes due to caving or collapsed formations
10 Any additional work not explicitly included in bid proposal
11 Traffic control measures
12 Noise Control (i.e.: sound panels or blankets)
13 Permits or licenses (i.e.: traffic control, encroachment, discharge, erosion control, etc.)
14 Sales tax or use taxes. (All applicable taxes will be added at time of invoicing)

Assumptions:

1 Work has been bid based upon the information provided to Holt with the following exclusions listed above. Work will be billed
2 Level drill pad 100' X 60' with access, adequate for 2WD rubber tired equipment accompanied by nearby staging area for semi
3 Drilling spoils and all fluids generated will be discharged to sumps or containers provided by others
4 An adequate water supply (2" line) will be provided at or near the drill site by the client at no expense to Holt.
5 Holt Can provide hauling services for transporting water to the drill site at 85.00/hr
6 All shift delays required for items such as insufficient access, water level measurements or client requested safety training/pauses,
7 Any re-drilling, hole conditioning or extra tripping of boreholes required will be charged at the provided rig hourly rate, plus
8 Annular material quantities that exceed 120% of theoretical annulus volumes will be billed at provided unit rates or cost plus 15%,
9 This proposal is subject to rig and crew availability. Neither party shall be bound by the terms of this proposal until a separate

Thank you for requesting this proposal from Holt Services. We look forward to the opportunity to work with you on this project.

Sincerely,

Robert Stadeli
Holt Services, Inc.
MBL: 503-572-9396
rstadeli@holtservicesinc.com

ATTACHMENT 8:
PRELIMINARY HYDROGEOLOGIC STUDY

Hydrogeologic Study

Corbett Water District

Corbett, Oregon

Prepared for:

Corbett Water District
36120 E. Historic Columbia River Hwy.
Corbett, OR 97019

Prepared by:

Mark Yinger, RG

MARK A. YINGER
G13[illegible]

Expires: 5/31/16

January 28, 2016
69860 Camp Polk Road, Sisters, OR 97759

Mark Yinger Associates

Table of Contents

Figures

Table

Appendix

1.0 Introduction

This report concerns the potential development of a groundwater source for the Corbett Water District, Corbett, Oregon. The Corbett Water District would like to construct a water well to supplement their current surface water source. The current source consists of two diversions: one the North Fork and one on the South Fork of Gordon Creek. The purpose of this study is to identify a site for a new water well.

2.0 Geographic Setting

The Corbett Water District is located in Oregon at the west end of the Columbia River Gorge. Corbett is the principle community in the water district (Fig. 1). The Sandy River borders the water district on the west and southwest. The Columbia River borders on the north. The water district is approximately 8.5 miles long, east to west, and approximately 3.2 miles wide, north to south. The elevation ranges from approximately 15 feet to 1,300 feet above mean sea level. The drainages are generally deeply incised and flow to the west and southwest to discharge into the Sandy River. A narrow band along the northern edge of the water district slopes steeply down to the Columbia River. The long-term average precipitation varies from approximately 45 inches at the district's west boundary to 80 inches at the east boundary. The long-term average precipitation for Troutdale, Oregon, just west of the district, is 44.9 inches (Western Regional Climate Center).

3.0 Hydrogeologic Setting

The geology of the Corbett Water District is complex due to the interplay of the ancestral Columbia River, uplift and volcanism of the Cascade Range, eruption of the flood basalts of Columbia River Basalt Group, and subsidence of the Portland Basin. Figure 2 is a compilation geologic map and Figure 3 is a generalized geologic cross-section. The geologic map is based on a U.S. Geologic Survey map of the Washougal Quadrangle (Evarts, Et al, 2103) and a Washington Department of Natural Resources map of the Vancouver Quadrangle (Phillips, 1987). The following description of the geology generally proceeds from the oldest rocks to the youngest.

Western Cascade Volcanics

Oligocene volcanic and sedimentary rocks of the Western Cascades likely underlie the entire Water District area. The oldest exposed rock in the Water District occurs along the shore of the Columbia River at Onion Rock (Evarts, Et al, 2013). The rock is a porphyritic andesite. The rocks of the Western Cascades are generally altered by low grade regional metamorphism resulting in secondary clay and zeolite minerals along joints, fractures and in vesicles, thus greatly reducing the permeability Oligocene rocks of the Western Cascades. The Oligocene volcanic and sedimentary rocks of the Western

Cascades are not considered a productive aquifer. There are many wells completed in these altered volcanics on the north side of the Columbia River that produce very little water. The few wells that produce significant volume likely intersect recent open fractures. The yield of these wells often decline significantly over time as the fractures are drained by pumping at a rate that exceeds recharge. These Oligocene volcanic and sedimentary rocks are the basement confining unit (Gannett and Caldwell, 1998).

Columbia River Basalts

The early to middle Miocene Grande Ronde Basalt flows of the Columbia River Basalt Group overlie the rocks of the Western Cascades on an erosional unconformity. The Columbia River Basalts are only exposed east of Corbett Station, on the lower portion of the steep slope that rises from the shore of the Columbia River. The Columbia River Basalts are considered an aquifer.

The Grande Ronde Basalt lava flows flowed west across the Cascade Range via a structural trough. The Grande Ronde Basalt likely underlies the entire Water District area. The Grande Ronde Basalt flows were of massive volume and each lava flow followed in rapid succession; flow on flow. Groundwater flow occurs along the contact zones between flows and cooling joints within the flows. Fracture zones associated with faults can locally greatly increase porosity and permeability resulting in very productive aquifers. The gouge (very finely ground and compressed rock) that occurs on a fault plane can be a very effective aquitard and as a result there can be significant changes in hydraulic head across a fault.

Middle Miocene Wanapum Basalt flows overlie the Grande Ronde Basalt on an erosional unconformity. The time span between the end of the eruption of the Grande Ronde Basalt and the start of the eruption of the Wanapum Basalt was long enough for significant erosion and sediment deposition to occur. This time span is called the Vantage Horizon. Fine grained sediments of the Vantage Horizon can act as effective aquitards restricting vertical movement of groundwater and significant changes in hydraulic head can occur across the Vantage Horizon. The Vantage Horizon period of time was long enough for the ancestral Columbia River to erode a canyon across the Cascade Range. In the study area, the Wanapum Basalt flows over-topped the canyon and flowed into Portland Basin. The last basalt flow was the Priest Rapid flow. At Crown Point the Priest Rapids flow fills a paleocanyon eroded into earlier Grande Ronde and Wanapum Basalt flows (Tolan & Beeson, 1984). At the base of the Priest Rapid flow is hyaloclastite that fills the bottom of the paleocanyon. The hyaloclastite deposit is well exposed at the base of Crown Point. The hyaloclastite was produced as the Priest Rapids lava flow encountered water and shattered into a mass of glassy fragments, ranging in size from sand to cobbles. At Crown Point the hyaloclastite is crudely bedded indicating that it was transported by water down the paleocanyon.

The time period between members of Wanapum Basalt was long enough for fine-grained soils and sediments to develop between flow members; these are generally referred to as interbeds. Due to the low permeability of these fine-grained interbeds they will act as aquitards between the basalt flow members. The rubbly, brecciated and vesicular zones at the top and bottom of basalt flows are much more permeable than interior of the flows where the permeability is limited to the relatively tight cooling fractures of the entablature and colonnade zones. In this setting the Wanapum Basalt flows have the potential to be productive aquifers.

Basin Fill Deposits – Troutdale Formation

From late Miocene through the Pliocene the Portland Basin subsided and was filled with fluvial and lacustrine sediments transported into the basin by the Columbia River and streams flowing off the Cascade Range (Evarts, Et al, 2013). These sediments occur at the surface over a large portion of the Water District, except where covered by a thick deposit of Quaternary loess and volcanic rocks of the High Cascades. This basin-fill unconformably overlies Columbia River Basalt. In the study area, the basin-fill sediments are mapped as the hyaloclastic sandstone member of the Troutdale Formation (Evarts, Et al, 2013). Beds and lenses of conglomerate occur within the hyaloclastic sandstone. The hyaloclastic sandstone member may be as thick as 600 feet. The sandstone consists of coarse to very coarse grained angular fragments of vitric and lithic basalt. The vitric fragments are largely altered to palagonite. Due to the alteration. the permeability of the hyaloclastic sandstone is expected to be low. Most of the wells in the study area are completed in the hyaloclastic sandstone and yields are small. The hyaloclastic sandstone is considered a confining unit and is correlative to the Willamette confining unit of Gannett and Caldwell (1998). The hyaloclastic sandstone will thin and possibly pinch out in the eastern portion of the Water District.

High Cascade Range Volcanics and Boring Lavas

Pliocene to Pleistocene age basalt and basaltic andesite flows overly the hyaloclastite sandstone in the eastern third of the study area, generally east of Crown Point. The mapped distribution of these flows suggest they flowed westward down a shallow slope into the Portland Basin (Evarts, Et al, 2013). Several basalt flows have been described as interbedded with the hyaloclastic sandstone member of the Troutdale Formation (Tolan and Beeson, 1984; Evarts, Et al, 2013). Flows of the High Cascades cap the ridge south of Howard Canyon and have an apparent thickness of approximately 400 feet. The geologic map compiled by Phillips (1987) shows almost all of the area east of Ross Mountain covered by High Cascade volcanics. Wells up to 215 feet deep northeast of the east end of the Water District and south of Pepper Mountain do not fully penetrate the High Cascade flows. Because these flows are relatively young, their permeability is expected to be relatively high.

Chamberlain Hill in the northwest corner of the Water District is a vent from which basalt lava flows and cinders erupted during the Pleistocene (Evarts, Et al, 2013). Basalt from Chamberlain Hill has been dated at 1.16 million years (Evarts, Et al, 2013). This vent is included with the many other vents of the Boring Volcanic Field.

Loess Deposits

Holocene age loess deposits cover large portions of the Water District. The loess is composed of fine sand and silt with thin paleo soil horizons within the loess deposits. The loess deposits likely have no potential to yield significant volumes of water to wells.

Geologic Structure

Two northwest trending faults have been mapped in the Corbett Station area (Evarts, Et al, 2013). One inferred fault, trending northeast, is mapped just north of Crown Point. The faults are shown the Figure 2, a geology compilation map. These faults offset the Grande Ronde and Wanapum basalts and the overlying hyaloclastite sandstone member of the Troutdale Formation. Combined, the three faults have dropped top of the Columbia River Basalt over 600 feet going from east to west across the faults (Evarts, Et al, 2013). As mentioned above, the fault planes may have very low permeability and the result would be a higher hydraulic head on the up-gradient side of the faults (east side). The fracture zones associated with the fault may significantly increase the permeability of the basalt.

4.0 Area Wells

Wells in the area of the Water District were researched using the Oregon Water Resources Department's well log database. Drillers file a log for each well they drill. The log provides information concerning the material drilled through, water bearing zones, water yield, and static water level. The logs for 112 wells located inside and outside of the Water District were reviewed. The well locations are shown on Figure 2. Selected data from the well logs is summarized in Table 1.

The majority of the wells are less than 300 feet deep and produce water from Troutdale Formation or the High Cascade Volcanics. The yield of these wells is generally less than 30 gallons per minute (gpm). Fifteen wells produce water from the Columbia River Basalt (CRB). The yield of these wells range from 6 to 100 gpm. The deepest well (MULT 73671), at 1,236 feet deep, is located on Evans Road and reportedly yields 100 gpm. At this well the top of the CRB is 510 feet beneath the surface and depth to static water is 560 feet. This deep well on Evans Road is located west of the two northwest trending faults. At a well (MULT 89326) located on Haines Road, east of the faults, the top of the CRB is 286 feet beneath the surface and the static water level may be 155 feet beneath the surface. The static water level in some of the wells completed in the CRB is below the top of the CRB. As mentioned above, the CRB generally occurs between two confining units.

5.0 Generalized Geologic Cross-Sections

To help visualize the subsurface in the study area, a generalized geologic cross-section was constructed that trends north-south from the Columbia River south to about Louden Road (Fig. 3). The A-A' cross-section line passes through Crown Point and the site of the Water District's water reservoirs. The cross-section is generalized; some of the geologic units are combined as there is insufficient data to map the individual members of the CRB. The basin-fill (Troutdale Formation) and the High Cascade volcanics are combined on the cross-section.

There are no wells in the plane of the cross-section. The wells shown are projected onto the cross-section. A hypothetical well is shown located at the water district's two reservoirs. The contact between the basin-fill and underlying CRB is likely to slope to the west-southwest into the Portland Basin. The well logs generally describe clay or claystone above the CRB. As mentioned earlier, the CRB is considered to occur between two confining units. Predicted groundwater flow directions are shown on the cross-section. The groundwater flow direction in the basin-fill/High Cascade volcanics is likely to follow the slope of the surface topography and discharge to streams in the Sandy River basin. A small amount of groundwater in the basin-fill/High Cascade volcanics will flow down into the CRB. West of the two faults, the CRB appears not to be saturated.

The groundwater flow divide in the CRB likely does not coincide with the drainage divide between the Columbia River and the Sandy River basin. This is due to the large vertical exposure of 700 to 800 feet of the CRB on the slope above the Columbia River. It is reasonable to conclude that the CRB groundwater flow divide is shifted to the south; into the Sandy River basin.

Cross-section B-B' trends north-south and is located just east of the Water Districts boundary (Fig. 3). The land owner at 45301 East Larch Mountain Road may allow the Water District to install a well on the property. A potential well is shown on the cross-section. No subsurface information is available in this area. The well site is located in the Latourell Creek/Columbia River drainage basin. The drainage divide between the Latourell Creek/Columbia River Basin and the Buck Creek/Sandy River Basin is approximately 500 feet south of the potential well site. It is presumed that a well at this location would intercept water that would have discharged to streams in both drainage basins.

6.0 Conceptual Hydrogeologic Model

Hydrogeologic units may consist of a single geologic unit, a portion of a geologic unit, or several geologic units. The components of a hydrogeologic unit have similar hydraulic properties. The hydrogeologic units in the study area are:

1. The basin-fill/High Cascade volcanics is the uppermost unit and watertable aquifer (unconfined). It consists primarily of the fine grained facies of the Troutdale Formation (hyaloclastite sandstone). Toward the eastern end of the Water District and water treatment plant, the Troutdale Formation will thin and possibly pinch out and the High Cascade Volcanics will thicken. Clay or claystone is common at the base of the unit and this limits the movement of water into the underlying CRB. The groundwater in this hydrogeologic unit discharges to streams in the Sandy River basin. The potential for recharge is high due to the abundant precipitation. The yield to wells is generally less than 30 gpm.

2. The CRB is the hydrogeologic unit underlying the basin-fill/High Cascades volcanics. Drainage from the 700 to 800 vertical feet of exposed CRB east of the northwest trending faults will cause the groundwater flow divide in the CRB to be shifted south into the Sandy River basin. Recharge of the CRB is limited by the low permeability of the clay and claystone that is generally present immediately overlying the CRB hydrogeologic unit. The permeability of interflow zones between basalt flows can be high. Low permeability fine-grained sediments can occur between individual members of the Wanapum Basalt leading to differences in hydraulic head between members. There is commonly a low permeability claystone or sandstone between the Wanapum Basalt and the underlying Grande Ronde Basalt, and this can result in significant differences in hydraulic head across the claystone or sandstone. Where the basalts are tectonically fractured, the permeability may greatly increase. The CRB can be a productive aquifer. In this setting, recharge is limited by the overlying and underlying confining units.

3. The underlying/basement confining unit is the Skamania volcanics. The permeability of these Oligocene volcaniclastics is very low. It is not considered an aquifer.

7.0 Groundwater Source Options

Four options for a new water well are discussed below.

Option One – E. Larch Mt. Road

A well could be constructed just north of East Larch Mt. Road, near the address of 45301. As mentioned above no subsurface information is available in this area. The High Cascade volcanics occur at the surface in this area. The depth to the underlying Basin Fill and CRB cannot be predicted. A well at this location would be in the Latourell Creek/Columbia River drainage basin. It can be presumed that more than 50% of the groundwater pumped from this well would have discharged to streams in the Columbia River Basin. It is possible that a well completed in the High Cascade volcanics could produce enough water to satisfy the Water District's needs.

Option Two – Well at Reservoirs #1 and #4

A well could be constructed at the location of the Water District's Reservoirs #1 and #4. This is the location of the hypothetical well shown on the geologic cross-section. The target aquifer is the CRB. Based on the foregoing discussion of geology and hydrogeology, a well at this location that is completed in the CRB will intercept water that would have discharged to the Columbia River.

The Oregon Water Resources Department has made a preliminary conclusion that a well at the Water District's treatment plant may impact threatened and endangered species (OWRD, 2015). Presumably a well at this location would intercept groundwater that would have discharged to Gordon Creek, a tributary of the Sandy River. However, a well at the location proposed above, that withdraws water only from the CRB, will not impact Gordon Creek or the Sandy River.

A well at the location of Reservoirs #1 and #4 should have a minimum planned depth of 1,000 feet. The water level in the CRB is not known at this location. The well casing would be sealed into the top of the CRB. The possibility of drilling a test well should be considered. If the test well is favorable in terms of yield, then a production well would be designed. Knowing the static water level and the water level while pumping would be useful for determining the diameter of a production well required to accommodate the pump. The design of a production well is largely dependent on diameter of the pump and motor needed to lift the water to the surface.

If a production well was drilled, then conservative assumptions would have to be made concerning what the pumping water level would be. Assuming the pumping water level is below the top of the CRB at 600 feet beneath the surface and the pumping rate is 400 gallons per minute (gpm), the pump motor would be 8-inches in diameter (75 hp). The permanent casing would be 12-inches in diameter and the steel liner in the open hole below the casing would be 10-inches in diameter.

Option Three – Corbett Station

An option would be to drill a well near Corbett Station, just to the east of the mapped northwest trending fault. A well at this location may encounter a permeable fracture zone in the CRB that could be hydraulically connected to the Columbia River. This would be a much shallower well. The problem, however, is the cost of a pipeline to get the water up to the system's reservoirs.

Option Four - Water Treatment Plant

An option would be a well at the water treatment plant. The well would be used for an aquifer storage system. Treated stream water would be injected into the well during the winter, when stream flow is high, and then withdrawn in the summer and fall as needed when the stream flow is low. This system would avoid impact to streams during low stream flow periods. Water that is injected and not recovered from the aquifer would return to streams in the Sandy River basin. It is likely that the storage would be in the High Cascade volcanics as the hyaloclastite sandstone may have pinched out and not be present. Little is known about the subsurface at the treatment plant. This option would require significant research and testing.

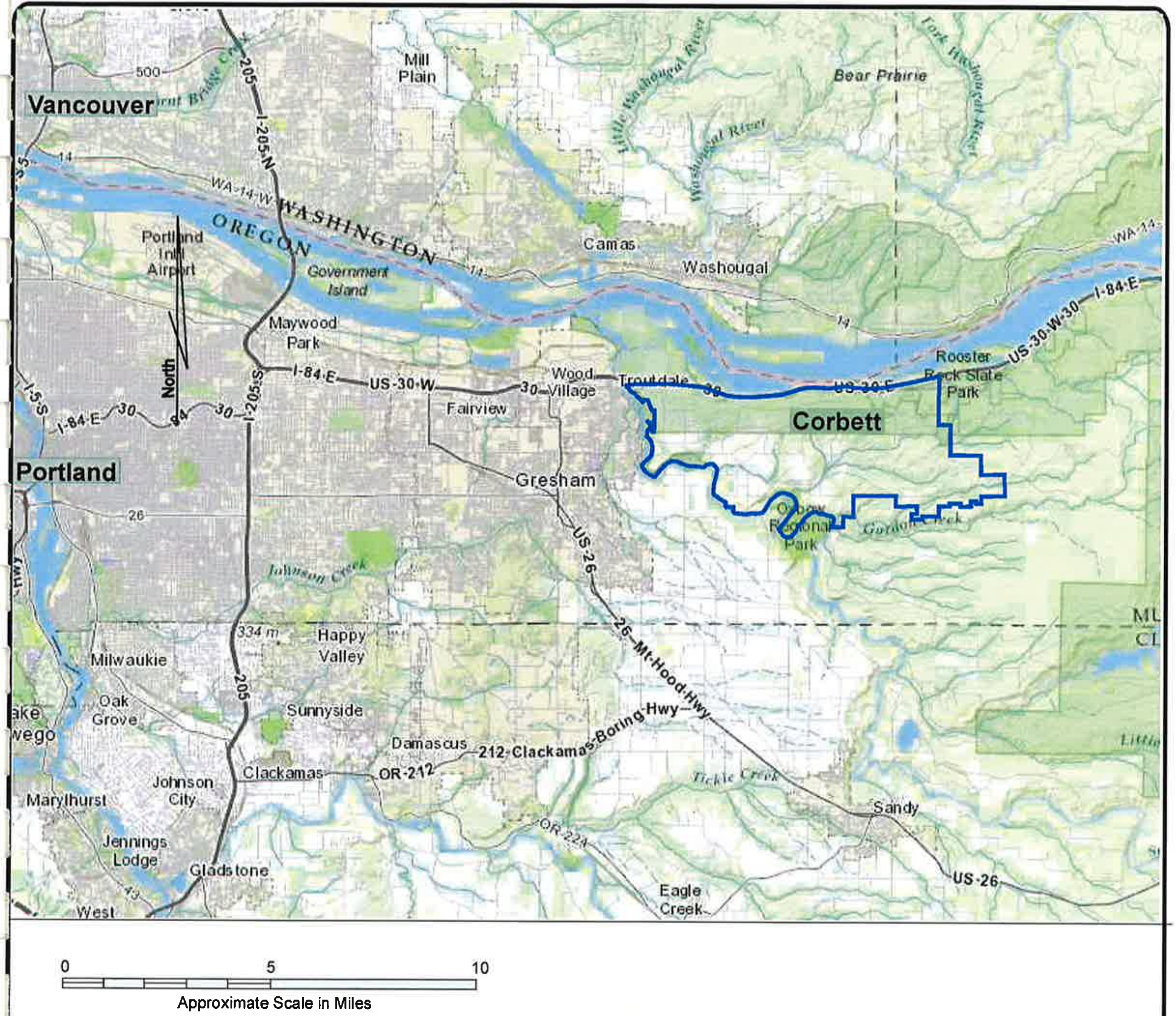
8.0 References

Evarts, Russell C., O'Connor, Jim E., and Tolan. 2013. Terry L. Geologic map of the Washougal Quadrangle, Clark County, Washington, and Multnomah County, Oregon. United States Geologic Survey Scientific Investigations Map 3257.

Gannett, Marshall W. and Caldwell, Rodney R. 1998. Geologic framework of the Willamette Lowland aquifer system, Oregon and Washington. Unites States Geologic Survey Professional Paper 1424-A.

Phillips, William M. 1987. Geologic map of the Vancouver Quadrangle, Washington and Oregon. Washington Department of Natural Resources Open File Report 87-10.

Tolan, Terry L. and Beeson, Marvin H. 1984. Exploring the Neogene history of the Columbia River: discussion and geologic field trip guide to the Columbia River Gorge. Oregon Department of Geology and Mineral Industries. Oregon Geology, Vol. 46, Number 8.

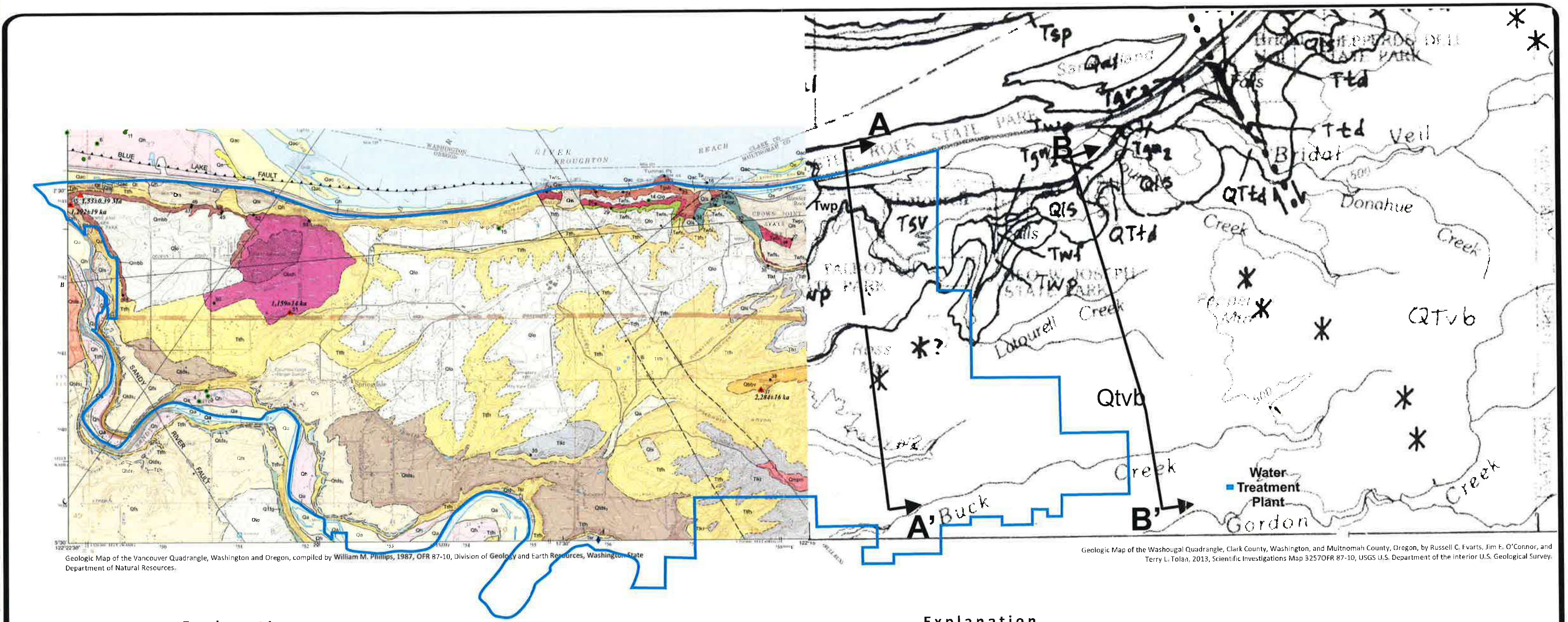


Hydrogeologic Study
Corbett Water District
Corbett, Oregon

Groundwater & Environmental Consultants
Mark Yinger Associates
69860 Camp Polk Road, Sisters, OR, 97759 - 541-549-3030

Figure 1
Corbett Water District Location Map

December 2015



Geologic Map of the Vancouver Quadrangle, Washington and Oregon, compiled by William M. Phillips, 1987, OFR 87-10, Division of Geology and Earth Resources, Washington State Department of Natural Resources.

Geologic Map of the Washougal Quadrangle, Clark County, Washington, and Multnomah County, Oregon, by Russell C. Evarts, Jim E. O'Connor, and Terry L. Tolan, 2013, Scientific Investigations Map 3257OFR 87-10, USGS U.S. Department of the interior U.S. Geological Survey.

Explanation

SURFICIAL DEPOSITS

Af	Artificial fill
Qe	Eolian deposits
Qac	Alluvium of Columbia River floodplain & channel
Qa	Alluvium
Qls	Landslide deposits
Qh	Deposits derived from the Mount Hood volcano
Qlo	Loess
Qtds$_2$	Terrace deposits 2
Qtds$_3$	Terrace deposits 3
Qfs	Sand and silt facies

VOLCANIC ROCKS OF THE BORING VOLCANIC FIELD

Qmpm	Basaltic andesite of Pepper Mountain
Qbch	Basalt of Chamberlain Hill
Qmbb	Basalt of Broughton Bluff
Qbbv	Basalt of Bridal Veil Creek

BASIN-FILL DEPOSITS

QTfg	Unnamed fan gravel
Ttfh	Hyaloclastic sandstone member Troutdale Formation
Tlkt	Volcanic rocks of the High Cascade Range

Columbia River Basalt Group

- Wanapum Basalt
  - Priest Rapids Member
    - TVpr$_R$ Basalt of Rosalia
  - Frenchman Springs Member
    - Twfs$_s$ Basalt of Sentinal Gap
    - Twfs$_h$ Basalt of Sand Hollow
- Grande Ronde Basalt
  - Tgsb Sentinal Bluffs Member

VOLCANIC AND SEDIMENTARY ROCKS

Ta	Volcaniclastic sedimentary rocks (Skamania volcanics)

Explanation

QUATERNARY SEDIMENTARY DEPOSITS

Qal	Alluvium
Qls	Landslide deposits

PLEISTOCENE-MIOCENE SEDIMENTARY DEPOSITS

QTtd	Troutdale Formation
QTvb	Volcanic Rocks Of the High Cascades
Tvs	Volcaniclastic sedimentary rocks (Skamania volcanics)

MIDDLE MIOCENE COLUMBIA RIVER BASALT GROUP FLOWS

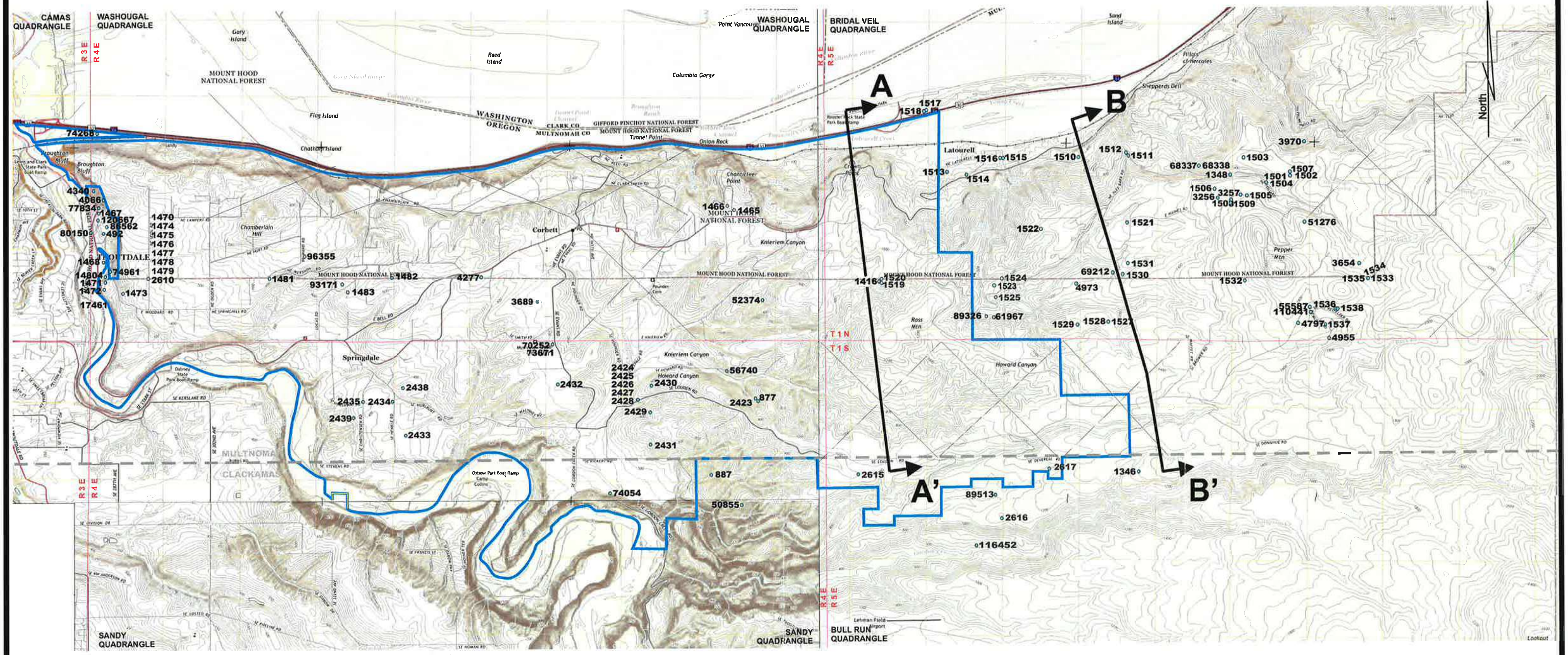
Tsp	Pomona Member of the Saddle Mountains Basalt
Twp	Priest Rapids Member of the Wanapum Basalt
Twf	Frenchman Springs Member of the Wanapum Basalt
Ttd	no explanation given
Tgn$_2$	Grande Ronde Basalt normal polarity
Tgr$_2$	Grande Ronde Basalt reverse polarity

Hydrogeologic Study
Corbett Water District
Corbett, Oregon

Groundwater & Environmental Consultants
Mark Yinger Associates
69860 Camp Polk Road, Sisters, OR, 97759 - 541-549-3030

Figure 2
Geology Map

December 2015



Note: The editions of USGS Maps used for this illustration do not have sections demarked and numbered.

KEY

Cross Section location

3689 ● Well log number and approximate location Wells with no address or quarter quarter section location are mapped in the center of the section.

Corbett Water District Boundary

Sections searched having no well logs

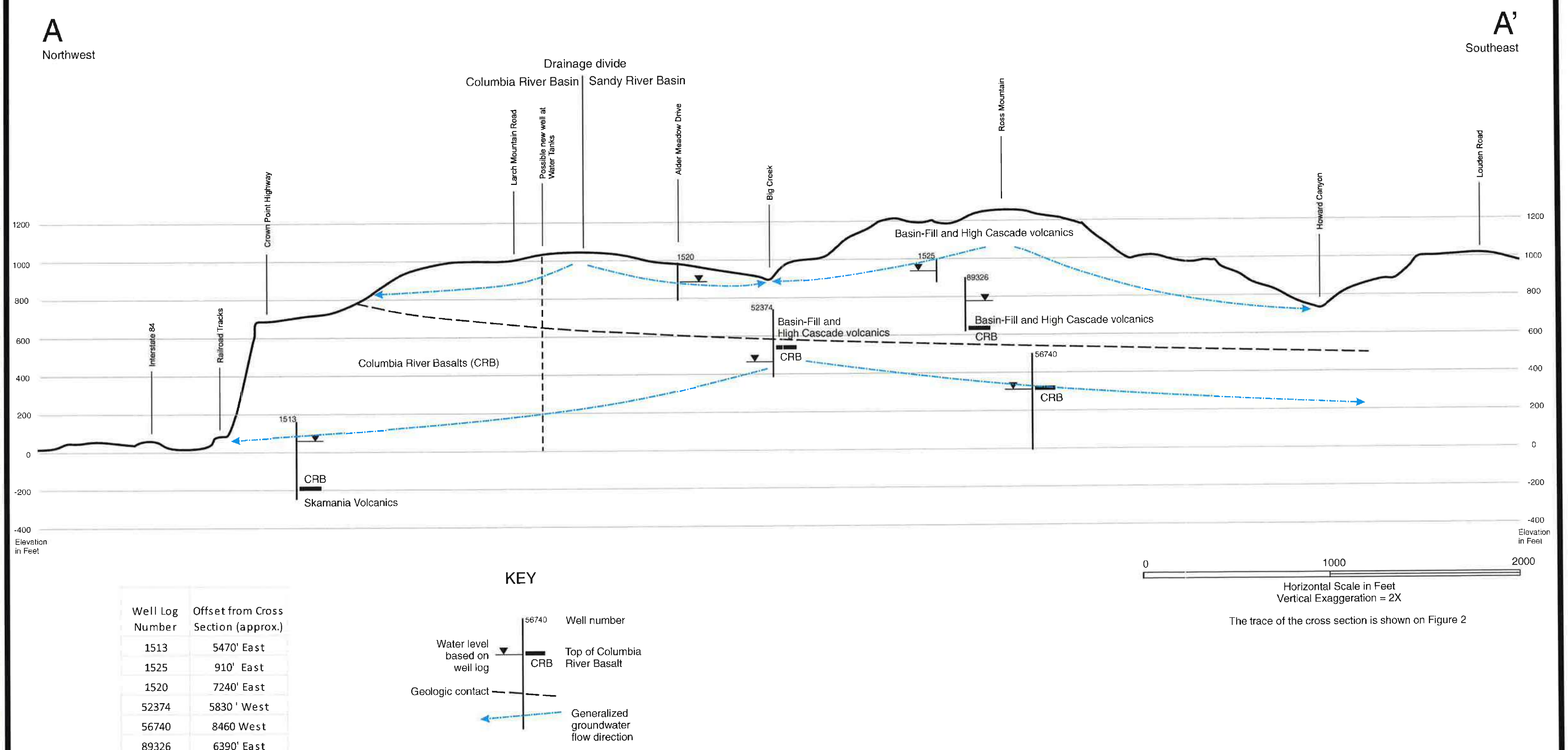
0 2000 4000 6000
Scale in Feet

Hydrogeologic Study
Corbett Water District
Corbett OR

Groundwater & Environmental Consultants
Mark Yinger Associates
69860 Camp Polk Road, Sisters, OR, 97759 - 541-549-3030

Figure 3
Well Location Map

December 2015



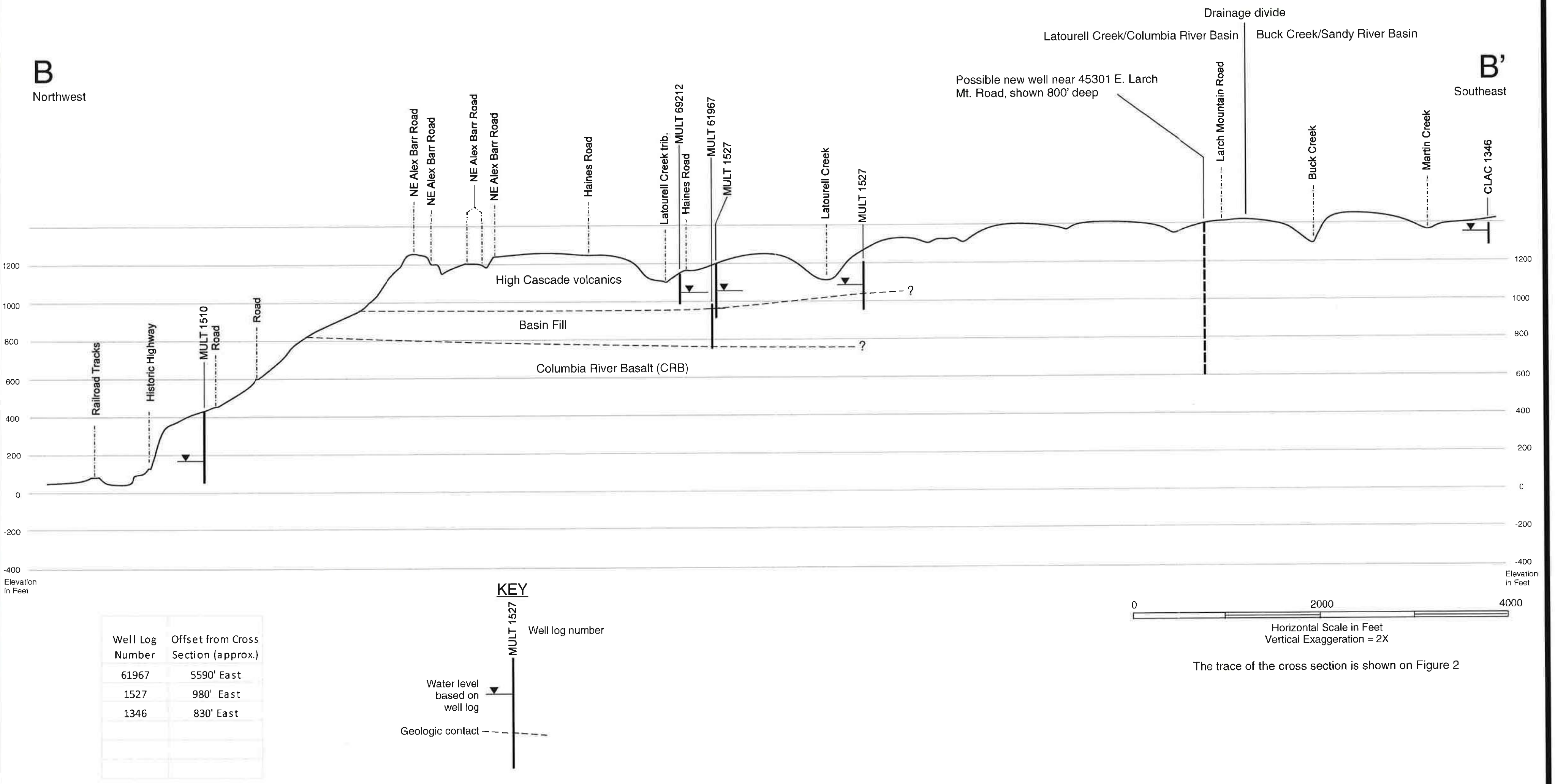
Well Log Number	Offset from Cross Section (approx.)
1513	5470' East
1525	910' East
1520	7240' East
52374	5830 ' West
56740	8460 West
89326	6390' East

Hydrogeologic Study
Corbett Water District
Corbett, Oregon

Groundwater & Environmental Consultants
Mark Yinger Associates
69860 Camp Polk Road, Sisters, OR, 97759 - 541-549-3030

Figure 4
Generalized Geologic Cross-Section A - A'

December 2015



Well Log Number	Offset from Cross Section (approx.)
61967	5590' East
1527	980' East
1346	830' East

The trace of the cross section is shown on Figure 2

Hydrogeologic Study
Corbett Water District
Corbett, Oregon

Groundwater & Environmental Consultants
Mark Yinger Associates
69860 Camp Polk Road, Sisters, OR, 97759 - 541-549-3030

Figure 5
Generalized Geologic Cross-Section B - B'

January 2016

Table 1: Corbett Water District - Data for Selected Wells

Well Number	Static Water Level (feet)	Well Depth (feet)	Production Zone Interval (feet)	Production Zone Thickness (feet)	Pumping Rate (gpm)	Drawdown$_1$ (feet)		tax lot / address / qq section	Comments
MULT									
1465	22	135	129-135	6	bailer- 20	20	1N_4E_25		
1466	17	122	115-122	7	bailer- 15	20	1N_4E_25		
1481	38	123	60-123	63	bailer - 10	67	1N_R4E_32		
96355	380	470	430-470	40	10	n/a	1N_R4E_32_SENE		Columbia River Basalt (CRB) at 240 feet?
1482	98	130	100-130	30	bailer - 20	2	1N_4E_33		
1483	144	255	236-253	17	74	24	1N_4E_33_NWSW		
94359	94	122	108-118	10	45	n/a	1N_4E_33_NWSW	33C; tax lot 900; 360 NE Lucas Road Troutdale	Production from Boring Lava 108-118 feet
3689	195	240	195-240	45	bailer - 15	0	1N_4E_34	5 SE Evans	
4277	268	439	283-412	129	98	84	1N_4E_34_NESW	33470 NE Old Columbia River Highway (Crown Point Highway)	Produces from Troutdale Formation (Fm), Oligocene claystone at 423 feet
52374	270	355	270-345	75	20	85	1N_4E_36_NENE	201 NE Salzman	CRB at 200 feet, static water level below top of CRB
1501	41	104	70-101	31	8	n/a	1N_R5E_27	tax lot 39;2023 NE Brower Road Coebwtt	
1502	180	586	?	?	6	n/a	1N_R5E_27	tax lot 39;2023 NE Brower Road Coebwtt	CRB 7-586 feet
1503	504	760	?	?	20+	n/a	1N_R5E_27	Henderson Road Bridal Veil	Wanapum Basalt 42-327 feet, Grande Ronde Basalt 327-760
1504	80	180	120-180	60	2.5	80	1N_R5E_27	2323 Brower Road Corbett	
1505	30	145	123-139	16	15	n/a	1N_R5E_27_SESW	1825 NE Brower Road Corbett	
1506	69	98	63-98	35	12	35	1N_R5E_27_SW		
1507	20	58	56-58	2	42	36	1N_R5E_27_NESE		Wanapum Basalt
1508	50	100	?	?	13	50	1N_R5E_27_SESW		
1509	70	130	87-123	36	12	55	1N_R5E_27_SESW		
3256	46	85	65-85	20	100	n/a	1N_R5E_27_SESW	tax lot30; 1701 Brower Road Corbett	Produces from High Cascade Volcanics
3257	35	125	92-125	33	100	n/a	1N_R5E_27_SESW	tax lot 21; 1805 Brower Road Corbett	Produces from High Cascade Volcanics
3970	no water	400	none	none	none	none	1N_R5E_27_SW	tax lot 25; 2827 NE Brower Road Corbett	CRB
68337	41	119	52-119	67	200	n/a	1N_R5E_27_SWSW	46312 NE Toll Road Corbett	Produces from High Cascade Volcanics
68338	88	303	132-153	21	1.5	n/a	1N_R5E_27_SWSW	46312 NE Toll Road Corbett	
1348 clac	35	70	35-70	35	20	35	1N_R5E_27_NESE		
115724	38	142	?	?	50	n/a	1N_R5E_27_SWSE	tax lot 1300; 1843 NE Brower Road Corbett	
1510	268	380	300-380	80	6	n/a	1N_R5E_28	tax lot 27, 44445 NE Alex Barr Road Corbett	CRB, static water level at river level
1511	80	110	102-110	8	bailer - 25	12	1N_R5E_28		CRB 65- 110 feet
1512	36	50	39-50	11	bailer - 8	7	1N_R5E_28		
1513	101	405	402-405	3	35	197	1N_R5E_29 _NENE	Talbot State Park	CRB24-365 feet, old Oligocene volcanics 365-406, static water level at river
1514	80	180	160-180	20	5	160	1N_R5E_29	tax lot 12 *(43401 NE Latourell Corbett)*	
1515	85	128	118-128	10	6	40	1N_R5E_29		
1516	22	120	57-20	63	60	28	1N_R5E_29	Guy Talbot State Park *(originally logged in section 30)*	In CRB, static above river level?
1517	30	165	160-165	5	85	44	1N_R5E_30_NENE	Rooster Rock Park	In sand and gravel
1518	20	144	134-144	10	55	25	1N_R5E_30 _NENE	Rooster Rock Park	
1416	160	300	275-285	10	10	50	1N_R5E_31		
1519	15	150	135-150	15	8	85	1N_R5E_31		CRB at 140 feet
1520	85	190	145-160	15	15	45	1N_R5E_31		
1521	118	230	217-225	8	11	30	1N_5E_32 _NENE	32aa; tax lot 10; 45505 NE Haines Road Corbett	
1522	65	120	80-120	40	bailer - 14	35	1N_R5E_32	tax lot 17; *(44443 E Haines Road Corbett)*	
1523	174	248	234-248	14	12	20	1N_R5E_32 NESW		
1524	385	425	375-475	100	bailer - 8	5	1N_R5E_32		
1525	102	129	112-129	17	40	4	1N_R5E_32_NESW		CRB at 110 feet
61967	115	240	140-240	100	12	45	1N_R5E_32_SWSW	42930 East Haines Road Corbett	
89326	155	320	292-315	23	10	50	1N_R5E_32_SESW	42900 East Haines Road Corbett	CRB at 286 feet,
1526	68	144	132-144	12	18	35	1N_R5E_33	33aa	
1527	126	280	260-280	20	bailer - 15	45	1N_R5E_33_SESW		
1528	none	290	n/a	n/a	3	n/a	1N_R5E_33_SWSW		
1529	143	287	240-245	5	8	135	1N_R5E_33		High Cascade Volcanics 42-240, Troutdale Fm 240- 287 feet
1530	120	158	128-142	14	10	20	1N_R5E_33		
1531	18	59	26-59	33	50	11	1N_R5E_33	West 1/2 of SW1/4 of the NE1/4	
4973	120	163	145-163	18	33	n/a	1N_R5E_33_SWSW	501 NE Thompson Creek Road	Produces from Troutdale Fm gravel
69212	97	160	120-160	40	25	63	1N_R5E_33_SWSW	529 NE Thompson Mill Road	
1532	290	360	?	?	bailer - 15	0	1N_R5E_34		
4797	42	120	90-100	10	15	50	1N_R5E_34 SESE	tax lot 9; 48000 E Larch Mountain Road Corbett	
4955	22	150	130-150	20	50	100	1N_R5E_34	tax lot 3; 540 SE Red Elder Road Corbett	
21276	108	215	175-205	30	75	107	1N_R5E_34		
1533	7	100	70-80	10	60	n/a	1N_R5E_35	6 miles past Larch Mountain Road	
1534	50	125	100-125	25	30	n/a	1N_R5E_35	6 miles past Larch Mountain Road	
1535	60	118	52-118	66	bailer - 6	56	1N_R5E_35		
1536	52	122	?	?	bailer - 8	40	1N_R5E_35_SW		
1537	49	95	55-95	40	7	40	1N_R5E_35_SWSW		
1538	40	78	72-78	6	bailer - 20	25	1N_R5E_35_SW		

3654	33	96	68-95	27	68	n/a	1N_R5E_35_SENW	tax lot 6; 555 SE Maffet	Produces from High Cascade Volcanics
55587	no log						1N_R5E_35E	tax lot 25; 22 SE Red Elder Drive Corbett	
110441	59	158	128-156	28	11	n/a	1N_R5E_35_SWSW	tax lot 1100; nearest address = 22 SE Hemlock Drive Corbett	
877	355	485	n/a	n/a	10	45	1S_R4E_1		
2423	n/a	288	250-285	35	bailer - 20	5	1S_R4E_1		
56740	n/a	500	n/a	n/a	n/a	n/a	1S_R4E_1	B-center	Claystone to 207 feet then CRB to 500 feet, no water in CRB, DOGAMI well
2424	45	114	105-109	4	bailer - 20	30	1S_R4E_2		
2425	103	135	115-128	13	bailer - 20	5	1S_R4E_2		
2426	50	116	86-116	40	bailer - 10	40	1S_R4E_2		
2427	38	75	45-70	3	bailer - 3	35	1S_R4E_2		
2428	75	122	88-120	32	bailer - 5	30	1S_R4E_2		
2429	185	580	n/a	n/a	bailer - 8	3	1S_R4E_2_NWSE		CRB at 509 feet
2430	47	76	n/a	n/a	bailer - 30	20	1S_R4E_2_SWNE		
2431	30	64	n/a	n/a	bailer	15	1S_R4E_2_SWSE		
2432	33	93	n/a	n/a	bailer - 18	2	1S_R4E_3		
70252	560	690	860-960	?????	40+	n/a	1S_R4E_3_NENE	tax lot 90	CRB at 510-960 feet, static water level below top of CRB
73671	deepening of 70252, water level did not change						1S_R4E_3	tax lot 100, 1307 SE Evans Road Corbett	Deepened 960-1236 feet, no change in static, yield increased from 40 to 100 gpm
2433	185	267	176-206	20	bailer - 10	15	1S_R4E_4_SWSE	tax lot 128;	
2434	133	162	162-167	5	30	12	1S_R4E_4	tax lot 50;	
2435	107	131	130-131	1	bailer - 20	12	1S_R4E_4_W1/2		
2438	64	102	n/a	n/a	10	40	1S_R4E_4_SWNE		
2439	35	96	n/a	n/a	9	n/a	1S_R4E_4_NWSW		
2615	225	250					1S_R5E_7_NENW	no log; tax lot 18	
2616	61	100	76-89	13	bailer - 36	2	1S_R_5E_8_NENE	Springdale	
2617	229	245	n/a	n/a	bailer - 5	0	1S_R_5E_8		
89513		90					1S_R_5E_8		
116452	286	382	363-382	19	15		1S_R_5E_8		
1346	49	109	87-108	21	bailer - 24	45	1S_R_5E_9		